LT-MAS Cooling System

- LT-MAS Cooling Cabinet

User Manual

Version 002

Innovation with Integrity

NMR / PCI

This manual was written by

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1 About This Manual

This manual enables safe and efficient handling of the device.

This manual is an integral part of the device, and must be kept in close proximity to the device where it is permanently accessible to personnel. In addition, instructions concerning labor protection laws, operator regulations tools and supplies must be available and adhered to.

Before starting any work, personnel must read the manual thoroughly and understand its contents. Compliance with all specified safety and operating instructions, as well as local work safety regulations, are vital to ensure safe operation.

The figures shown in this manual are designed to be general and informative and may not represent the specific Bruker model, component or software/firmware version you are working with. Options and accessories may or may not be illustrated in each figure.

1.1 Policy Statement

It is Bruker's policy to improve products as new techniques and components become available. Bruker reserves the right to change specifications at any time.

Every effort has been made to avoid errors in text and Figure presentation in this publication. In order to produce useful and appropriate documentation, we welcome your comments on this publication. Field Service Engineers are advised to check regularly with Bruker for updated information.

Bruker is committed to providing customers with inventive, high-quality, environmentally-sound products and services.

1.2 Symbols and Conventions

Safety instructions in this manual and labels of devices are marked with symbols. .

The safety instructions are introduced using indicative words which express the extent of the hazard.

In order to avoid accidents, personal injury or damage to property, always observe safety instructions and proceed with care.

⚠ DANGER

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

This is the consequence of not following the warning.

1. This is the safety condition.

▶ This is the safety instruction.

⚠ WARNING

WARNING indicates a hazardous situation, which, if not avoided, could result in death or serious injury.

This is the consequence of not following the warning.

1. This is the safety condition.

▶ This is the safety instruction.

⚠ CAUTION

CAUTION indicates a hazardous situation, which, if not avoided, may result in minor or moderate injury or severe material or property damage.

This is the consequence of not following the warning.

1. This is the safety condition.

▶ This is the safety instruction.

NOTICE

NOTICE indicates a property damage message.

This is the consequence of not following the notice.

1. This is a safety condition.

▶ This is a safety instruction.

SAFETY INSTRUCTIONS

SAFETY INSTRUCTIONS are used for control flow and shutdowns in the event of an error or emergency.

This is the consequence of not following the safety instructions.

1. This is a safety condition.

▶ This is a safety instruction.

This symbol highlights useful tips and recommendations as well as information designed to ensure efficient and smooth operation.

1.3 Font and Format Conventions

Type of Information	Font	Examples
Shell Command, Commands, "All what you can enter"	Arial bold	Type or enter **fromjdx zg**
Button, Tab, Pane and Menu Names "All what you can click"	Arial bold, initial letters capitalized	Use the **Export To File** button. Click **OK**. Click **Processing**…
Windows, Dialog Windows, Pop-up Windows Names	Arial, initial letters capitalized	The Stacked Plot Edit dialog will be displayed.
Path, File, Dataset and Experiment Names **Data Path Variables** **Table Column Names** **Field Names (within Dialog Windows)**	Arial Italics	*$tshome/exp/stan/nmr/lists* *expno, procno,*
Parameters	Arial in Capital Letters	VCLIST

Program Code
Pulse and AU Program Names
Macros
Functions
Arguments
Variables
	Courier	`go=2`
		`au_zgte`
		`edmac`
		`CalcExpTime()`
		`XAU(prog, arg)`
		`disk2, user2`

AU Macro	Courier in Capital Letters	`REX` `PNO`

Table 1.1: Font and Format Conventions

About This Manual

2 Introduction

26/9/ 2011	V0.1	PATK	Creation
28/08/2012	V1.0	PATK	Released
27/05/2016	V2.0	PATK	New cabinet, exchanger safety valve

Table 2.1: Document Revision

This document is the user manual of the LT MAS cooling system with Bruker part number **W1101514** or **W124429 (**with new exchanger V3**)**.

2.1 Intended Use

The LT-MAS cooling cabinet is designed to produce very cold gases required for operating the low temperature MAS probe (LTMAS probe).

The equipment cools the VT, BEARING and DRIVE gases using liquid nitrogen as coolant.

The cooling system is contained in a cabinet equipped with a heat exchanger assembly and its control electronics.

A vacuum jacketed transfer line transfers the cold gases to the LTMAS probe. The cabinet contains several control units and a rotary vane vacuum pump producing the vacuum of the system.

The device has been designed and constructed solely for the intended use described here. Intended use also includes compliance with all specifications within this manual.

Any use which exceeds or differs from the intended use shall be considered improper use. No claims of any kind for damage will be entertained if such claims result from improper use.

Part Number	Description	Quantity
W158231	LT-MAS transfer line V2	1
W145967	Heat exchanger assembly V3	1
1805554	LN2 tank 60 liter	1
W1101611	LT-MAS exchanger control unit	1
H13000	MAS/2 unit	1
W1101515	BVT3000 LT-MAS	1
W1101590	LT-MAS pneumatic unit	1
W1101589	LT-MAS LN2 refill line	1
W1101609	LT-MAS storage tank pressurization panel	1
W132722	LT-MAS cabinet	1
W146342	LT-MAS vacuum pump & vacuum lines	1
W1101634	LT-MAS accessories set	1
1803973	LN2 dispense plug for tank	1
W124228	LN2 reservoir lid	1
W124607	Gas return line from probe	1

Table 2.2: List of Material of Cooling System P/N: W124429 (version 3)

2.2 Limitation of Liability

All specifications and instructions in this manual have been compiled taking account of applicable standards and regulations, the current state of technology and the experience and insights we have gained over the years.

The manufacturer accepts no liability for damage due to:

- Failure to observe this manual.
- Improper use.
- Deployment of untrained personnel.
- Unauthorized modifications.
- Technical modifications.
- Use of unauthorized spare parts.

The actual scope of supply may differ from the explanations and depictions in this manual in the case of special designs, take-up of additional ordering options, or as a result of the latest technical modifications.

The undertakings agreed in the supply contract, as well as the manufacturer's Terms and Conditions and Terms of Delivery, and the legal regulations applicable at the time of the conclusion of the contract shall apply.

2.3 Copyright

2.4 Warranty Terms

The warranty terms are included in the manufacturer's Terms and Conditions.

2.5 Product Safety and Electromagnetic Compatibility

The device complies with the standard

- IEC 61010-1 and with UL 61010-1 / CSA C22.2 No. 61010-1-04 Safety Requirements for Electrical Equipment.
- IEC 61326-1 for Electromagnetic Compatibility (EMC).

3 Safety

In order to minimize health hazards and to avoid dangerous situations, follow the safety instructions specified here as well as in the other chapters of this manual.

Non-compliance with the action guidelines and safety instructions contained in this manual may result in serious hazards.

3.1 Liquid Nitrogen Safety

⚠ WARNING

Danger of injury

In order to ensure optimal personnel protections by handling cold objects and liquid nitrogen make sure to:

- ▶ Wear hand protection and goggles (not safety glasses) dispensing and handling liquid nitrogen. When handling cold objects and liquid nitrogen, hands should be protected by protective cryogenic gloves against cold (consistent with the EN 511).
- ▶ Eye Protection: when handling the liquid, splashes are always possible and eyes must be protected by goggles protection (conforming to EN166) or visors.

4 Transport, Packaging and Storage

Installation, initial commissioning, retrofitting, repairs, adjustments or dismantling of the device must only be carried out by Bruker Service or personnel authorized by Bruker. Damage due to servicing that is not authorized by Bruker is not covered by your warranty.

4.1 Symbols on the Packaging

The following symbols are affixed to the packaging material. Always observe the symbols during transport and handling.

Top		The arrow tips on the sign mark the top of the package. They must always point upwards; otherwise the content may be damaged.
Fragile		Marks packages with fragile or sensitive contents. Handle the package with care; do not allow the package to fall and do not allow it to be impacted.
Protect Against Moisture		Protect packages against moisture and keep dry.
Attach Here		Lifting gear (lifting chain, lifting strap) must only be attached to points bearing this symbol.
Center of Gravity		Marks the center of gravity of packages. Note the location of the center of gravity when lifting and transporting.
Weight, Attached Load		Indicates the weight of packages. Handle the marked package in accordance with its weight.

Permitted Stacking Load		Indicates packages which are partially stackable. Do not exceed the maximum load-bearing capacity specified on the symbol in order to avoid damaging or destroying the content.
Do not Damage Air-tight Packaging		The packaging is air-tight. Damage to the barrier layer may render the contents unusable. Do not pierce. Do not use sharp objects to open.
Component Sensitive to Electrostatic Discharge		The packaging contains components which are sensitive to an electrostatic discharge. Only allow packaging to be opened by trained personnel. Establish potential equalization before opening.
Protect from Heat		Protect packages against heat and direct sunlight.
Protect from Radioactive Sources		Protect packages against radioactive sources.

Table 4.1: Symbols on the Packaging

4.2 Inspection at Delivery

Upon receipt, immediately inspect the delivery for completeness and transport damage.

Proceed as follows in the event of externally apparent transport damage:

- Do not accept the delivery, or only accept it subject to reservation.
- Note the extent of the damage on the transport documentation or the shipper's delivery note.
- Initiate complaint procedures.

Issue a complaint in respect to each defect immediately following detection. Damage compensation claims can only be asserted within the applicable complaint deadlines.

4.3 Packaging

About Packaging

The individual packages are packaged in accordance with anticipated transport conditions. Only environmentally friendly materials have been used in the packaging.

The packaging is intended to protect the individual components from transport damage, corrosion and other damage prior to assembly. Therefore do not destroy the packaging and only remove it shortly before assembly.

Handling Packaging Materials

Keep the original container and packing assembly, at least as long the warranty is valid, in case the unit has to be returned to the factory. When the packaging material is no longer needed dispose of in accordance with the relevant applicable legal requirements and local regulations.

4.4 Storage

Storage of the Packages

Store the packages under the following conditions:

- Do not store outdoors.
- Store in dry and dust-free conditions.
- Do not expose to aggressive media.
- Protect against direct sunlight.
- Avoid mechanical shocks.
- Storage temperature: 15 to 35 °C.
- Relative humidity: max. 60%.
- If stored for longer than 3 months, regularly check the general condition of all parts and the packaging. If necessary, top-up or replace preservatives.

Under certain circumstances, storage instructions may be affixed to packages which expand the requirements specified here. Comply with these accordingly.

Transport, Packaging and Storage

5 Technical Data

5.1 General Features Cabinet with Exchanger V3

P/N W124429

The cooling system uses liquid nitrogen to cool all LTMAS probe gases (VT, Bearing and Drive gas).

Temperature control range	95 K to 300 K, the exchanger by-pass mode can be used to operate the probe at room temperature or to warm up the probe.
User interface	Color touch screen
Remote probe temperature control	EDTE program, requires TOPSPIN 2.1 with patch Level 2 or later

5.2 Liquid Nitrogen and Nitrogen Gas Consumption

Inlet nitrogen gas pressure	6-8 bar, up to 215 l/minute max. (Standard Temperature Pressure)
Liquid nitrogen consumption	6 to 10 l/hour LN2 Liquid nitrogen consumption increases with the spinning rate
Nitrogen gas exhaust from the from exchanger into lab	13.5 m3/hr. max
Liquid nitrogen tank refill	By automatic level controller AMI model 186

5.3 Power Requirements and Dimensions

Line voltage	230V AC 50/60 Hz +/- 10%
Power ratings	2500 Watt
Cabinet dimensions	**Version 1:** before 9/2012 210 (H) × 101 (D) × 80 cm (W) on casters. 220 (H) × 115 (D) × 94 cm (W) with crate on palett. **Version 2** : since 9/2012 188 (H) × 101 (D) × 80 cm (W) on casters 195 (H) × 115 (D) × 94 cm (W) with crate on pallet.
Weight	approx. 500 kg with liquid nitrogen full reservoir and exchanger assembly inside cabinet

6 Design

Figure 6.1: LTMAS Cooling Cabinet V2

NB. Since September 2012 the new cabinet (Version 2) has a reduced height.

Design

7 Principle of Heat Exchanger Operation

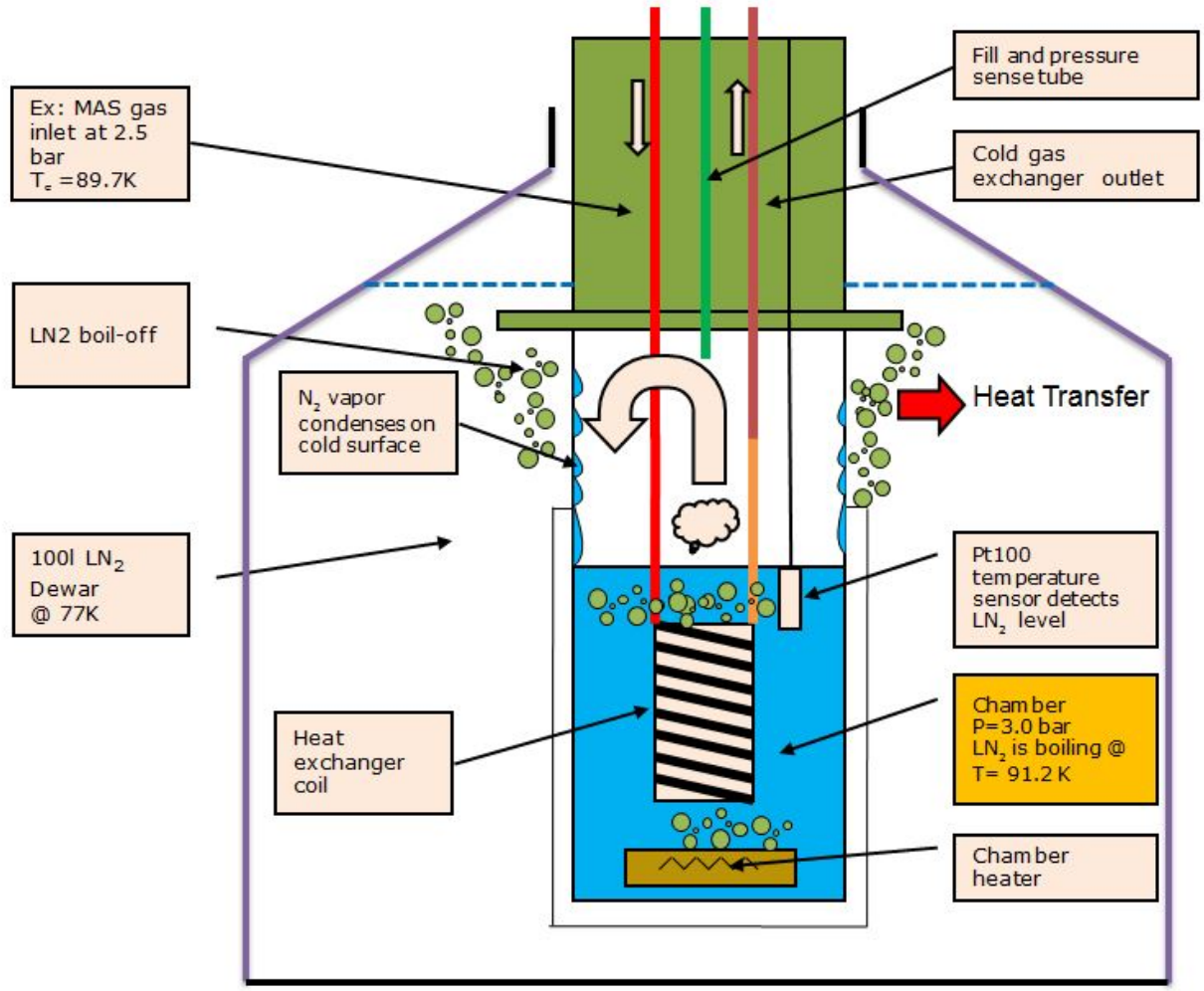

Figure 7.1: Exchanger Principle

- At the bottom of the exchanger assembly comprises three closed chambers containing each a heat exchanger. The heat exchanger is a helical coiled tube immersed in LN_2 contained in the chamber. The gas is cooled when it passes through exchanger coil.
- The temperature of boiling liquid nitrogen within the chamber is constant when the pressure is kept constant.
- The temperature of the boiling LN_2 is directly related to the chamber pressure.

⚠ CAUTION

Risk of damage due to improper use of the exchanger assembly

Risk of rotor crash.

- ▶ The temperature of the boiling LN2 in a chamber must be always above the condensation temperature of the gas circulating in the exchanger coil. This condition means **Pchamber > P MAS**.
- ▶ It is mandatory for the user to always take care to control the chamber pressure in respect of this general rule to avoid a rotor crash.

Here a setup example for the bearing gas chamber pressure:

If **BEARING** gas pressure delivered by MAS2 unit is **2.5** bar the gas in the exchanger coil will condense on any surface colder than **89.6** K.

You will have to set **Bearing** chamber pressure to control the bearing chamber pressure at

P = **3.0** bar, a margin of 0.5 bar is sufficient.

With these conditions, the LN_2 inside the chamber is boiling at **91.2K** and the MAS bearing gas flowing through the exchanger coil can't condense.

The pressure tube in has two functions. Firstly it is used to fill the chamber and secondly it is directly connected to a pressure sensor used to measure the chamber pressure.

The chamber heater in the chamber bottom controls the chamber pressure to keep the pressure constant.

See also

Principle of Heat Exchanger Operation [▶ 25]

7.1 Description of Main Cabinet Components

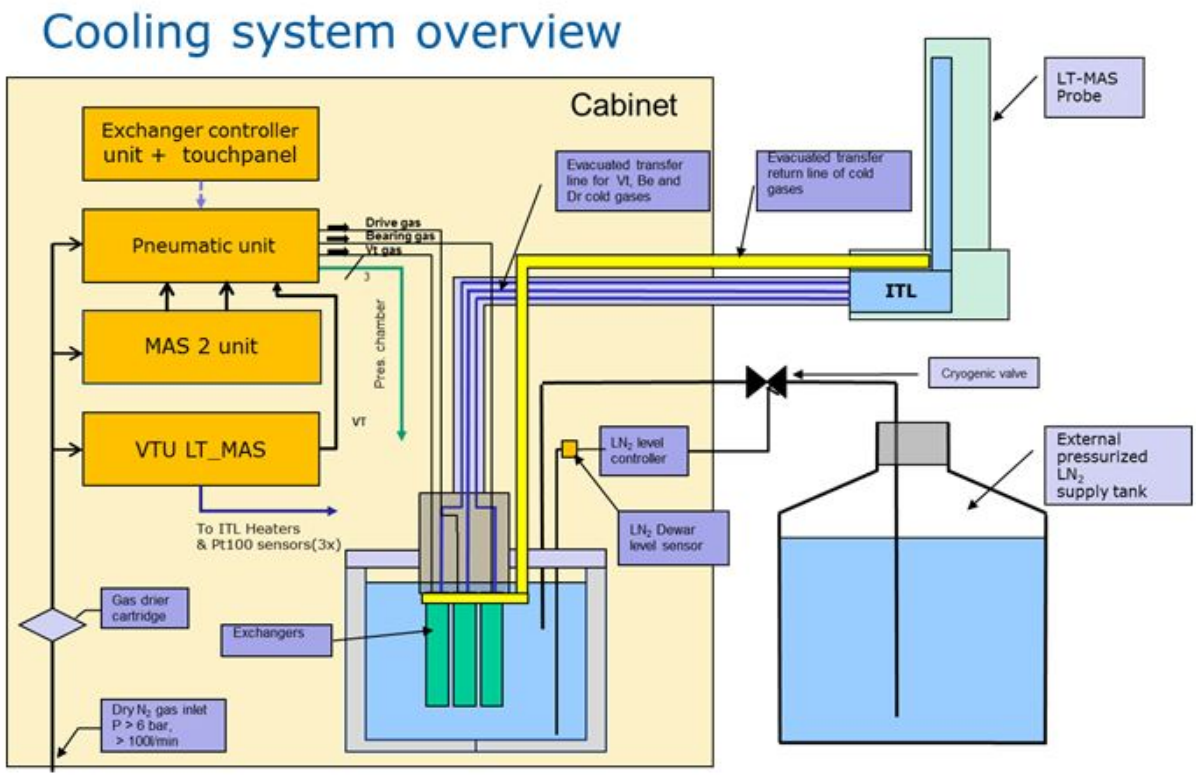

Figure 7.2: Cooling System Exchanger V2 with External Supply Tank

- Main gas inlet valve (1/4 turn valve) on rear cabinet side
- Inlet drier filter cartridge
- BVT3000 LT-MAS temperature control unit
- MAS/2 unit
- Pneumatic unit
- Exchanger controller with touch panel
- Exchanger assembly and LN2 tank
- Vacuum jacketed gas transfer line
- Gas return line from probe
- LN_2 refill line with cryogenic valve.
- LN_2 level controller with level sensor
- External pressurized LN_2 storage tank

7.2 BVT3000 LT-MAS

Probe variable temperature unit, part number: **W1101515**

Figure 7.3: BVT3000 LT-MAS Front Panel

7.2.1 Description

The BVT3000 unit controls the temperature of probe gases: VT, Bearing and Drive. It is equipped with a gas flow meter measuring the VT gas flow through the unit.

The pneumatic unit has three mass sensors gas flow for VT, Be and Dr. Each mass flowmeter delivers an electrical signal enabling the associated probe heater operation (Bearing & drive Flow connector). If a gas flow is missing or too low the probe heater can't be switched **ON**.

The cable from the pneumatic unit MUST be connected to the "**Bearing and DRIVE flow**" connector located on the right side of the BVT3000 front panel.

The RS232 connector located on the left side is used for the remote control with the EDTE program.

The ITL Heater cable is attached on plug marked "**Probe Heater**". The ITL is the Internal transfer Line which is located inside probe.

The thermocouples from the LT probe are connected to the **AUXILIARY SENSOR** module:

- The probe "**VT"** thermocouple is plugged on **CH0**, it measures the temperature close to the stator.
- The "**EXHAUST"** thermocouple is plugged to **CH3**, it measures the probe gas exhaust temperature.

The VT gas flow can be varied between 0 to approx. 35 l/min with the EDTE program *(TOPSIN 2.1 PL2 or later is required).*

For the remote operation of the BVT, it must be connected to the spectrometer console with a RS232 cable (to TTY port 4 or 5). The VTU RS232 plug is located on the rear side of the cabinet (bottom left side).

The probe heater must be switched to ON, to really apply a gas flow rate modification done in EDTE.

After powering up the BVT3000 the default flow is set to approx. 5l/min.

The temperature type selector, (present only on oldest BVT3000 LTMAS) must be on position PT100 to measure the probe temperatures inside the probe ITL.

7.2.2 GYROTRON Interlock

The GYROTRON should only emit microwave power to probe when the probe is cold enough to avoid any damage to the sample or to the probe.

The BVT3000 measures always the temperature of the VT gas inside probe ITL. If the temperature is low enough (the threshold is factory set to **180** K), it enables the Gyrotron emission of microwave.

If the probe temperature is below the temperature threshold, a blinking message **"1FSL"** appears on the VT Eurotherm controller. This is not an error message. It means that the GYROTRON interlock is enabled.

The interlock cable **MUST** be connected between the BVT3000 "**GYROTRON INTERLOCK**" plug on front panel and the GYROTRON control cabinet.

If the cable is disconnected the GYROTRON operation is disabled and it can't emit microwave power.

7.3 Pneumatic Unit

Part number: **W1101590**

Figure 7.4: LT-MAS Pneumatic Unit V2, Front View

Upper Panel Row	
VT Chamber , Bearing Chamber, Drive chamber.	Mass flow meter showing the amount of gas entered in the chamber (in liter) or (l/min). The volume counter is reset while pressing both arrows simultaneously.
Pressure	Pressure (bar) of exchanger chamber.
Lower Panel Row	
VT Flow, Bearing Flow, Drive Flow	Flow meters that measure the gas flow of VT, MAS Bearing and MAS Drive (l/min).
VT pressure, MAS Bearing, MAS Drive	Pressure measured at the inlet of the exchanger coil (bar).

The pneumatic unit is mainly used to fill the exchanger chambers with liquid nitrogen and to control all chamber pressure. It contains the power electronics necessary for the control of the chamber heaters.

It contains pressure sensors and gas flow meters for all three MAS gases. The pneumatic unit contains three groups of solenoid valves (and three solenoid valves per gas channel).

Each exchanger chamber is connected to a gas circuit composed of three valves and additional pneumatic components:

- Fill valve (FV)
- Vent Valve (VV)
- Gas valve (GV)
- The **FILL VALVE** is used to fill the chamber with nitrogen gas that produces liquid nitrogen inside the very cold chamber. This valve is normally closed.
- The **VENT** valve is only used to release the gas pressure of the chamber or to completely empty the chamber for a service operation, for example. It is not used for the normal operation.
- The **GAS VALVE** has two positions: **BY-PASS** or **COOLING**.

When the gas valve is set to the **COOLING** position, the gas flows through the exchanger coil and is cooled.

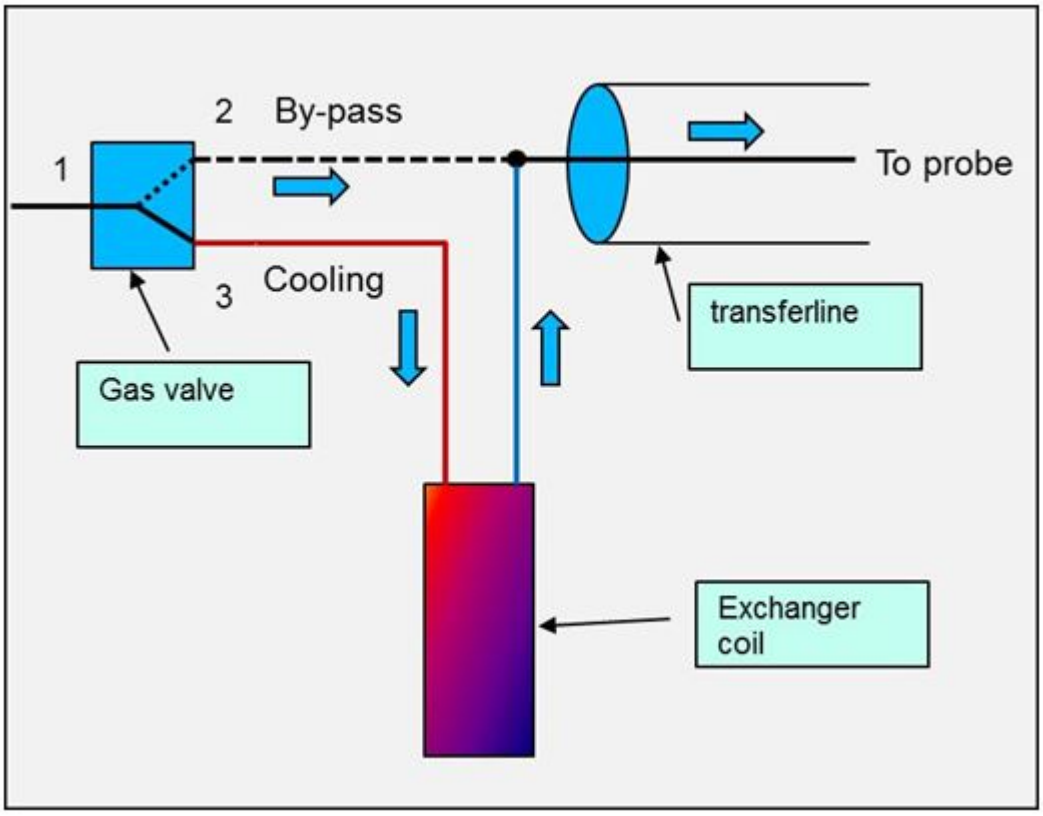

Figure 7.5: Gas Valve and by-Pass Function

The **BY-PASS** position is used to deliver gas at room temperature directly to the probe. The gas doesn't pass through the exchanger coil. This position is useful to rapidly warm-up the probe with gas at room temperature.

The by-pass position is also used when exchanger is not in operation, for the permanent probe flushing, avoiding moisture ingress in the exchanger and probe.

The pneumatic unit front panel has pressure indicators and gas flow meters.

The pressure or flow indicators are identical for all three gas channels.

7.4 LT-MAS Exchanger Control Unit

Part number: **W1101611**

This unit contains the system controller. It is a PLC (Programmable Logic Controller) that controls all operations of the cooling system, including gas valves operation and chamber heaters control. The user can read much information and can input commands on the associated touch panel.

7.4.1 LN2 Liquid Level Controller

Part number: **W1101608** (when mounted aside)

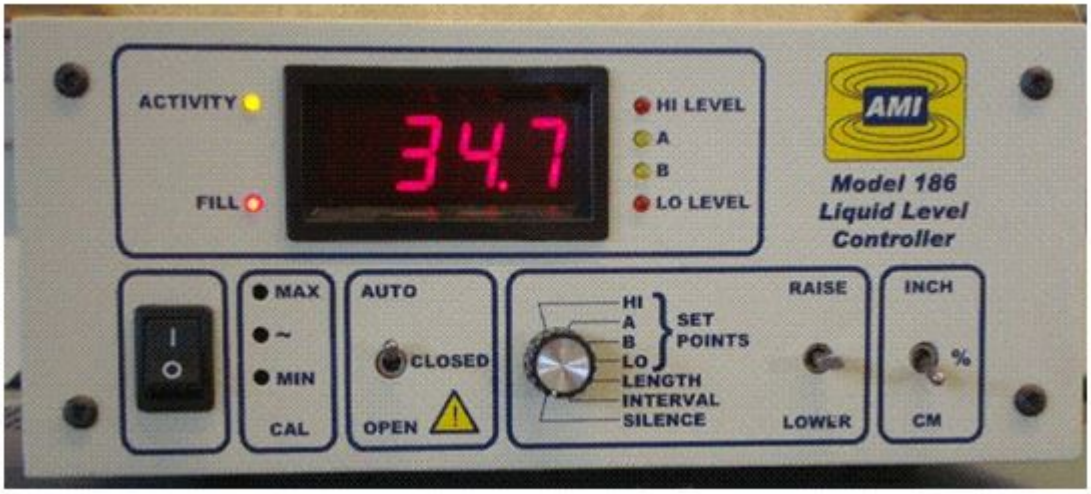

Figure 7.6: LN2 Level Controller

The LN_2 level controller (AMI model 186) is mounted inside on the front panel of the control unit. The liquid level controller automatically controls the LN_2 level in the exchanger reservoir. It uses a capacitive sensor level gauge that is plunged into the exchanger LN_2 reservoir.

The LN_2 level sensor is connected to a small preamplifier box that converts the sensor capacitance into an electrical signal readable by the level controller. Do **not** replace the BNC cable between level senor and preamplifier because the level measurement will be wrong.

In **AUTO** mode the controller keeps the LN_2 level always between the upper level set point “A” and the lower level set point “B”. These levels are set to insure that the whole external surface exchanger chamber is immersed in LN_2.

When the **Fill** led lights, the controller energizes the cryogenic valve attached at end of filling line.

The cryogenic refill valve operation is controlled by a three positions switch:

AUTO	This mode is the normal mode of the cooling system.
OPEN	The refill cryogenic valve is **OPEN**. **DO NOT USE THIS MODE.**
CLOSED	The cryogenic valve is **CLOSED**.

The level display units are must be set to “**Cm**” (centimeter) selected by a switch on the right side.

⚠ CAUTION

Damage due to liquid nitrogen reservoir overflow

If the switch is in position “**OPEN**” it can lead to an overfilling of the LN_2 tank and the spilling of liquid nitrogen.

- ▶ The switch must be in position **AUTO** during normal system operation.
- ▶ The position **CLOSE** is used to stop the automatic refilling of the LN_2 exchanger tank.
- ▶ **DO NOT** USE the position “**OPEN**”.

7.4.2 LN2 Capacitive Level Gauge

The liquid nitrogen level in the exchanger reservoir is measured with a capacitive level sensor . The sensor tube passes through the lid of the reservoir and has a “BNC” style electrical connector. The tip of the gauge tube is located typically about 1 cm above the bottom of the reservoir.

⚠ CAUTION

Risk of malfunction of LN_2 Level Sensor

The level sensor is sensitive to moisture. If the sensor is removed from a cold tank it will be covered with frost very rapidly. The sensor will not indicate the correct liquid level in the tank. This can lead to a malfunction of the whole cooling system.

- ▶ Before re-installing the sensor it is mandatory to warm up the whole active sensor length and dry it very carefully with a hot air gun at moderate temperature, for example, to remove any trace of moisture or frost inside sensor tube.

7.5 MAS 2 Unit

Part number: **H13000**

This unit gas has several functions:

- It serves to insert or eject the sample rotor from the probe.
- It controls the spinning rate of the rotor by adjusting **the Bearing** and **Drive** pressure.

The MAS2 is equipped with a touch screen interface.

The RS232 cable must be connected between the console and cabinet rear side to allow the remote control of the MAS2 unit.

The MAS 2 unit should have **ECL3** or higher. If the ECL is lower than ECL3, the MAS 2 unit should be permanently flushed with a small flow of dry nitrogen gas to avoid any moisture ingress that can possibly create sample insert and eject problems. A spare plastic tubing behind the left side panel is available for this function and can be connected to the rear side of the MAS2 unit.

7.6 Vacuum Pump

A rotary vane vacuum pump is located in the lower part left side of the cabinet. It produces the high vacuum is necessary to reduce the heat load on the transfer line and probe ITL and get the best performance of the cooling system.

The vacuum pump is connected to several devices that are all thermally insulated by vacuum:

1. The exchanger housing assembly.
2. The cold gas transfer line to probe.
3. The ITL (Internal Transfer Line) located inside the probe base. The external vacuum line to ITL is terminated by vacuum valve operator.

The vacuum is monitored by a vacuum gauge (yellow vacuum gauge) located at the pump suction port near exchanger.

On the sensor front panel when **both** leds light (**GREEN** and **RED**), the vacuum units are 10-3 mbar.

The system vacuum is considered good when the vacuum is below **10x10-3** mbar. The vacuum pressure can also be read on the touch panel of the cooling cabinet (“Vacuum and LN2” menu, “Vacuum Level”).

A vacuum above **10x10-3 mbar** doesn’t permit to reach very low temperature inside probe.

On the vacuum pump suction port is located a vacuum safety valve that closes the vacuum line immediately in case of line voltage outage.

The vacuum pump is be turned on and stopped in the “**Vacuum an LN2”** menu. Do not operate the pump using its On/Off button.

Principle of Heat Exchanger Operation

8 Cooling Cabinet Installation

8.1 Site Planning

The cooling cabinet must be installed indoor only in a dry room.

- Altitude max: 2000 meter.
- Humidity 80 % non-condensing.
- Temperature in operation 15-32 °C.
- A one meter wide clearance area on all sides of cabinet is necessary for the handling of the liquid nitrogen external storage tank.
- The cabinet must be installed in a magnetic field below **5 GAUSS**.

⚠ WARNING

Hazard due to low oxygen content in air

The LTMAS in operation delivers continuously nitrogen gas into the room.

- ▶ The room where the cooling system is installed must have a volume of at least 20 m^3.
- ▶ It must be well vented by appropriate means to evacuate all nitrogen gases produced by the cooling system and the gas released by the LTMAS probe. The oxygen content of the air must be monitored by an oxygen sensor alarm system.

8.2 Cabinet Installation

The rear side of the cabinet must face the NMR magnet and point towards the probe gas inlet. The exchanger transfer line is approx. 3.0 meter long. On the left or right side of the cabinet there must be enough space to place a LN_2 storage tank. The LN_2 refill line to storage tank is two meter long.

The rear side of the cabinet must be located approx. 2.5 meter away from the geometric center of the magnet to enable an easy connection to the LTMAS probe.

The probe transfer line installed between cabinet and probe should not make a sharp curve towards probe to ease its connection to probe. A straight line to probe is the best position.

8.2.1 How to Remove the Wood Pallet

Figure 8.1: LTMAS Cabinet on Pallet

⚠ CAUTION

Mechanical danger due to moving mechanical parts

The cabinet side panels are metallic and can be attracted by the magnet.

▶ Do not approach the magnet with the panels because they will be very strongly attracted by the magnet.

The cabinet is attached on a pallet and it can be moved with a pallet jack.

- Remove the crate side panels and the top of crate.
- Open both side panels of the cabinet and disconnect the protective ground wires from panels. Remove side panels.
- Remove the screws from wooden plate; they are inside cabinet above the wood blocks.

- Lift the cabinet with the pallet jack.
- Remove the wooden blocks on both sides of cabinet (remove all the screws inside cabinet).
- Lower the pallet jack and remove it.

8.2.2 Nitrogen Gas Supply and Power Supply

- Connect the nitrogen gas supply tubing 8 mm to a gas supply point (gas pressure **6 to 8 bar**, flow >100 l/min STP).

The supply tubing must be PE or HDPE to avoid moisture trap.

The gas pressure should be preferably regulated by a pressure regulator.

If the inlet pressure is below 6 bar the MAS2 may not function correctly.

- Connect the power cord to a 230 Volt wall socket. Plug the power cord to the power socket on rear side of cabinet.
- Power ON cabinet (press button marked “ **I**” on front side switch).
- Power ON all electronic units inside cabinet.

8.3 Unpack the Cardboard Box

The big cardboard box contains several accessories. Some must be assembled or mounted on exchanger housing. It contains the following items:

- Gas transfer line for LTMAS probe.
- Cold gas return line from probe.
- A set of flexible vacuum lines with vacuum seals and clamping rings.
- Vacuum accessories: KF tees, KF elbows (KF stands for **K**lein **F**lange).
- Two unassembled stands for the transfer lines.
- HDPE tubing 8 mm diameter.

8.4 Assembling Exchanger

8.4.1 Cabinet Version 1 (before 9/2012)

A removable platform is fixed on the right side of the chassis. It makes the handling of the tank and exchanger easier during installation or service. Pull it outwards and remove it from cabinet chassis.

Lay down the platform on the floor and secure it to the frame cabinet with the two pins on both sides. Unlock the sliding carriage by lifting and rotating the two side locking handles.

The LN_2 tank with exchanger can then be moved outside cabinet on the sliding carriage.

8.4.2 New Cabinet Version 2 (after 9/2012)

The cabinet height is smaller than version 1.

The movable carriage has been suppressed and the exchanger assembly is now placed on a square stainless steel tray equipped with four casters.

8.4.3 Installing Casters on Exchanger Tray

The casters on the exchanger tray are delivered in reversed position for the transport.

The casters position must be reversed to touch the floor and support the exchanger tray. For this the bracket of each caster is hold by a pin that must be removed.

The tray casters allows moving the exchanger tray outside cabinet if necessary for service for example.

The tray is guided on both sides inside the steel rails.

Remove tray locking screws on both rails.

Remove the knurled screws and the chassis bar and pull out the exchanger tray from cabinet.

8.4.4 Exchanger Installation

The exchanger housing is fixed on the lid of the 60 l liquid nitrogen tank.

It is highly recommended to be assisted by a second person for the gas transfer line installation on exchanger housing.

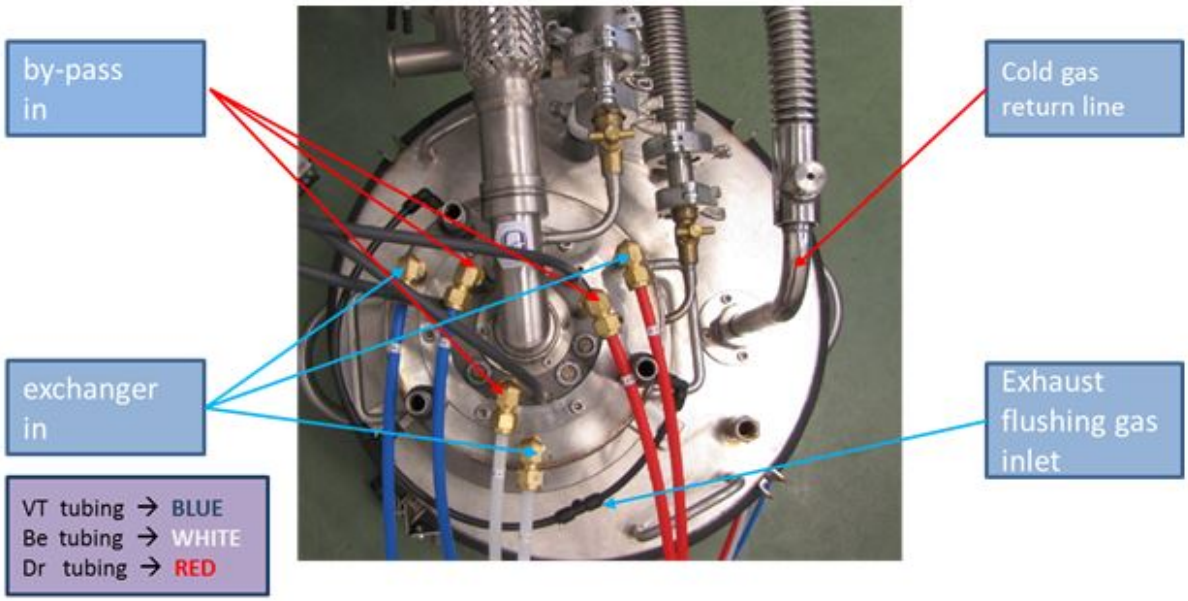

Figure 8.2: Exchanger Installation

8.4.4.1 Installing Transfer Line on Exchanger V2

The gas transfer line stored in the cardboard box must be installed on top of the exchanger housing of the exchanger V2.

Remove the protective PVC grey plastic disk from top of exchanger and store thoroughly the six screws.

NOTICE
Please be careful! **Screws must not drop inside exchanger.**

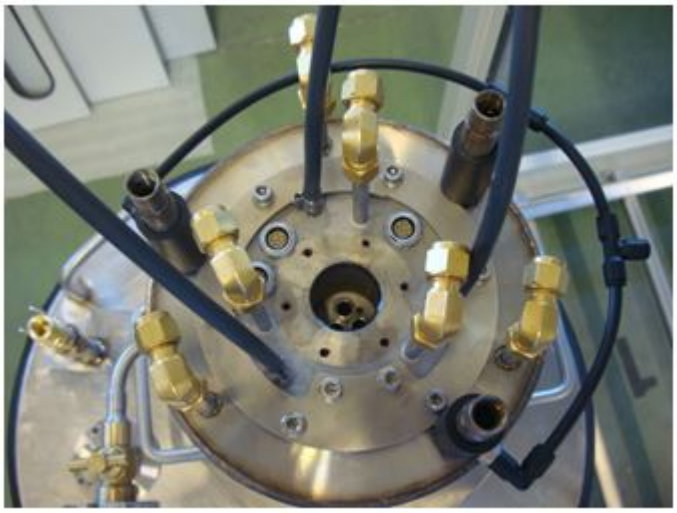

Figure 8.3: Exchanger without Transfer line

NOTICE
Please note the correct orientation of the transfer line: The hole -mark- on the transfer line and hole in exchanger inlet must correspond.

A 8 mm o’ring seals must be installed on each tube at the end of the transfer line.
Engage very carefully and slowly the three tubes inside the exchanger bores.
When the transfer line is completely inserted, secure it with the six screws.

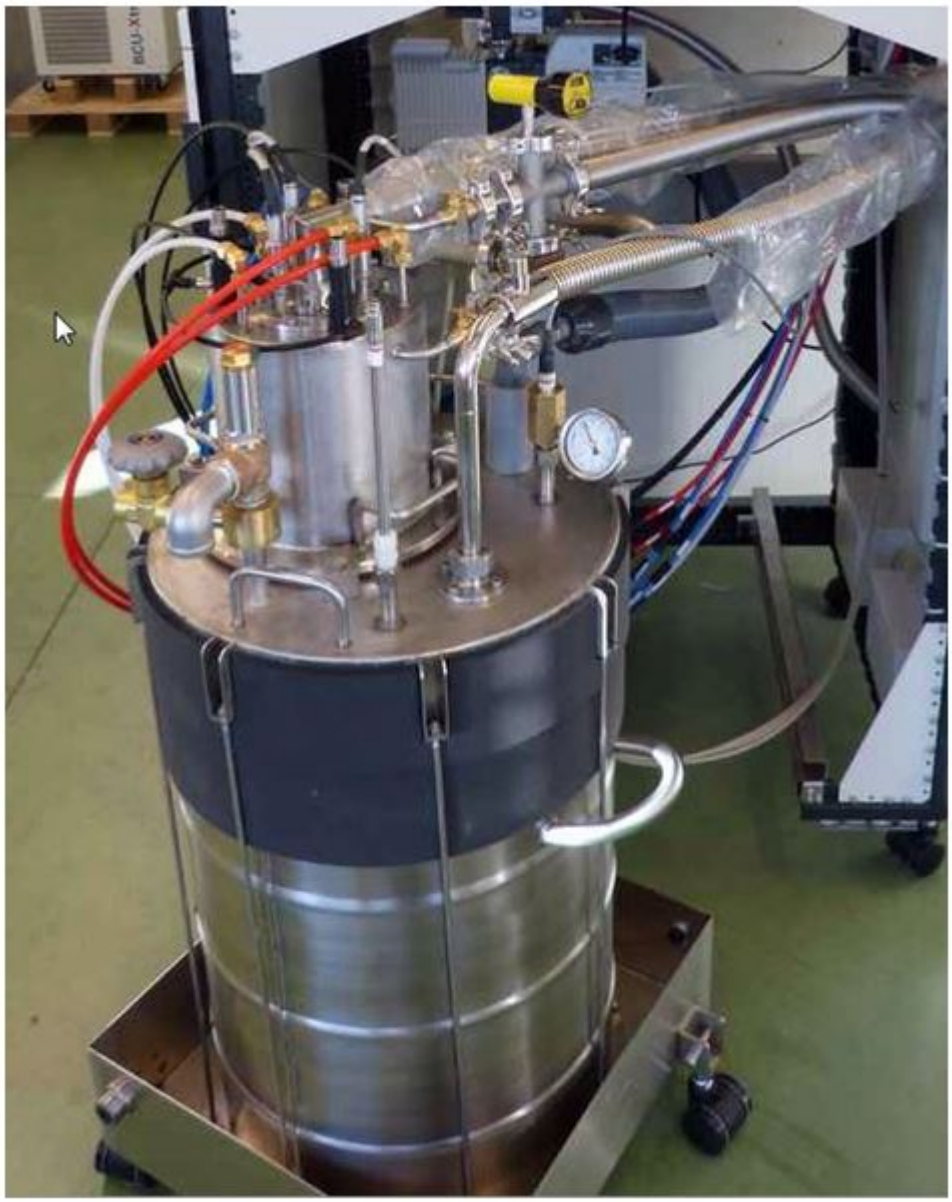

Figure 8.4: Exchanger Assembly with LN2 Reservoir

8.4.4.2 Install Probe Gas Return Line on Exchanger

The new exchanger V3 was designed to reduce dramatically the liquid nitrogen consumption of the cooling system. It uses the cold boil-off gas and the cold gas returning from the probe for the precooling of the exchanger MAS gases.

The evacuated return line must be connected between LT probe and exchanger reservoir lid.

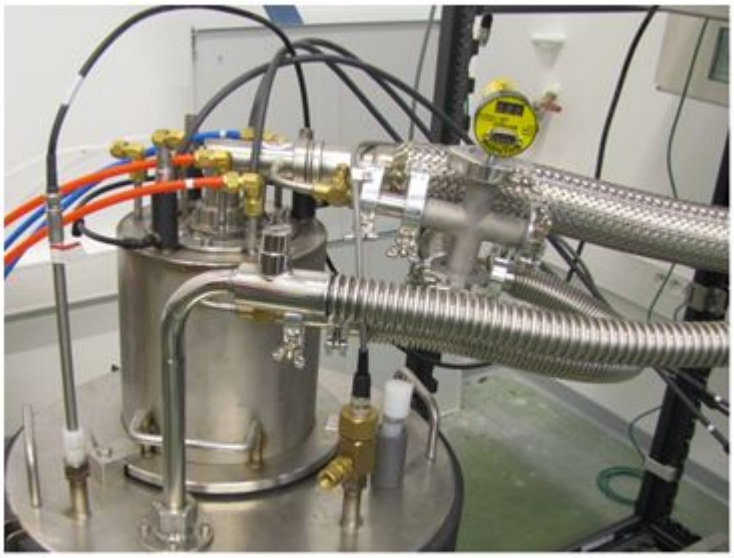

Figure 8.5: Gas Return Line Installed

Pass the straight part of the return transfer line through the opening of rear panel.
Install the return line leg in the reservoir cover and tighten the nut by hand.
Insert the return line in probe base and tighten the knurled nut by hand.

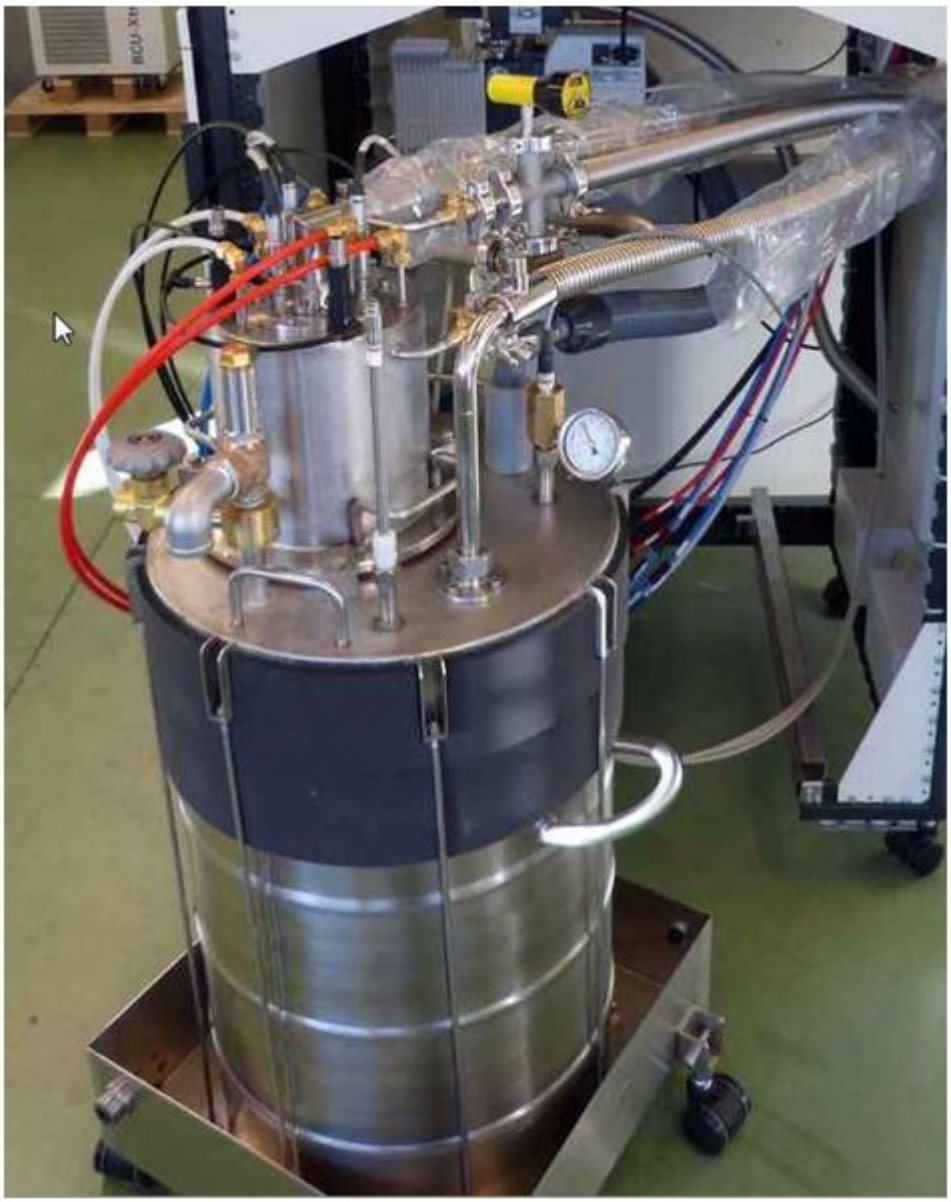

Figure 8.6: Heat Exchanger View

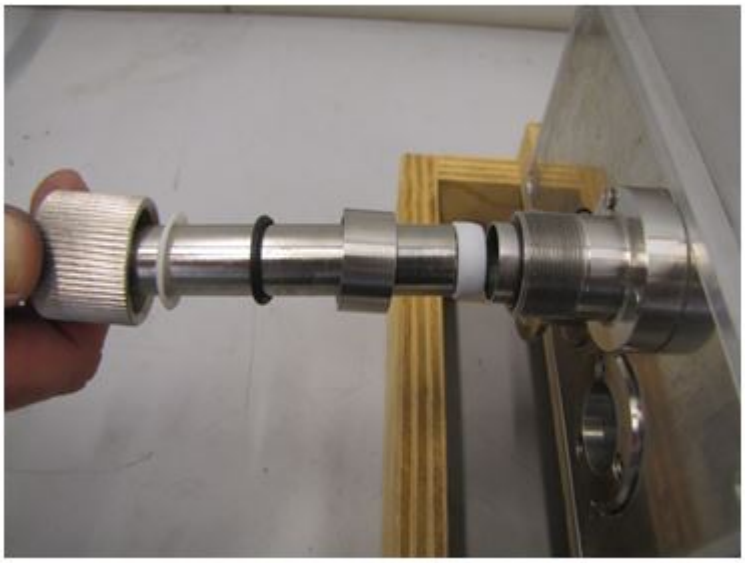

Figure 8.7: Connexion of Return Gas Line on Probe

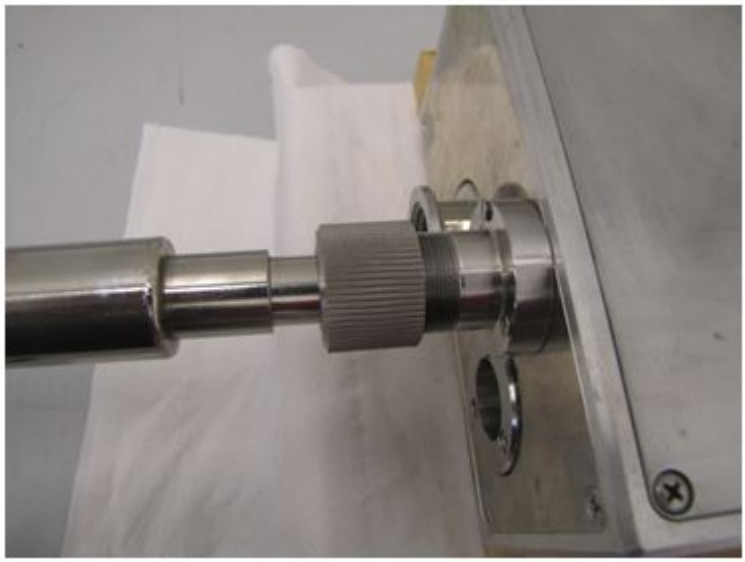

Figure 8.8: Gas Return Line attached to Probe

See also

Install Probe Gas Return Line on Exchanger [▶ 40]

8.4.4.3 Install Exchanger Electrical Cables and Tubings

- Plug the three electrical cables on the exchanger plugs, the cable connectors are marked with labels (VT, BE, DR) and cannot be mixed. A wrong cable connection will be detected by the controller.
- Connect the exchanger **FILL** tubes (3 tubes) to their respective plastic tubes equipped with quick push in fittings.

- Attach all tubing's to the by-pass and exchanger "SWAGELOCK" fittings (6 x) and tighten with fingers the nuts. Then tighten more all fittings by hand until it blocks. Continue with a wrench and tighten only **1/4 turn**.
- Attach the cable to sensor LN_2 level sensor.

8.4.4.4 LN2 Insulated Filling Line

Connect the LN_2 insulated refill line to exchanger refill inlet fitting. Two wrenches are required for this operation. With one wrench hold the fixed fitting and with the other wrench screw the filling line nut.

8.4.4.5 Vacuum Lines Connections

NOTICE
Please note: The V2 cabinet is delivered with all the vacuum devices mounted. The description below concerns only the V1 cabinet.

- Install all vacuum components with vacuum gauge on exchanger housing with seals and clamps as shown on figures.

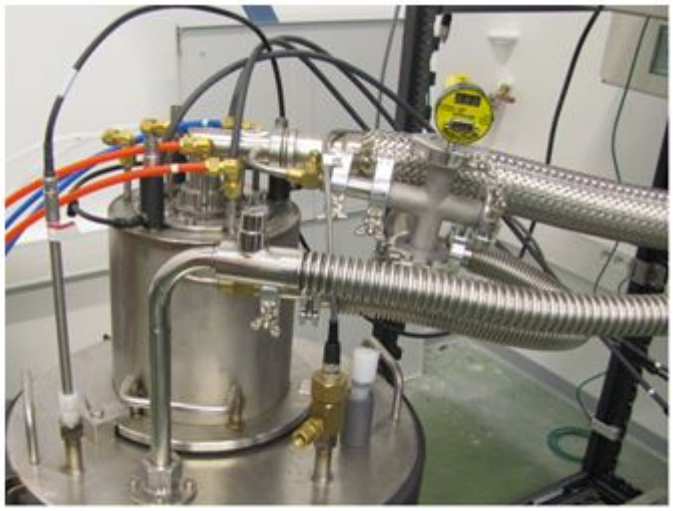

Figure 8.9: Vacuum Components Side View

Figure 8.10: Vacuum Components Top View

The central element is a KF25 cross on which the other vacuum components are attached.

On top of the cross is mounted the vacuum gauge (yellow gauge).

On left side is mounted a reducer to DN16 attached on the transfer line vacuum port manual valve.

On bottom is attached a 90° right angle elbow followed by a KF25 tee. The middle of the tee is connected to the exchanger body vacuum valve equipped with a manual valve (1/4 turn) with a short flexible DN25.

The open end of the tee will be connected later to the vacuum pump by a flexible tubing DN25 once the exchanger assembly is inside installed in the cabinet.

The right side of the tee will receive the external vacuum 2 m line that is attached to probe ITL:

- Connect the vacuum gauge cable and secure it.
- Connect the LN2 level sensor cable.
- Connect the 6 mm purge black tubing on exchanger body. This tube delivers a small flow of dry nitrogen gas to all three exchanger outlets tubes to avoid the excessive freezing of the outlets.
- Push the exchanger assembly inside cabinet and connect the vacuum flexible line between vacuum pump and tee.
- Assemble two vacuum hoses DN25 (2x1 m) with seals and clamps. Pass the line through the back panel opening and attach the line to the DN25 cross (on right side). This external vacuum line is used to pump the vacuum of the ITL (located inside LT probe base).
- Install the in line manual valve at the end of the vacuum line.
- Attach a 1 m vacuum hose.

8.4.4.6 Install Vacuum Valve Operator on Probe

We assume that the LT-MAS probe is already installed in the NMR magnet.

- Attach the vacuum valve operator at the end of the vacuum line coming from the cabinet with seal and KF25 clamp.
- The vacuum port of the ITL is closed by a small plug.
- Unscrew slightly the operator's hex nut, do not remove it completely. There is an O-ring seal inside the nut. Place the adapter over vacuum valve and tighten slightly by hand.
- When you feel that the o'ring seal is over vacuum port groove tighten the hex nut with fingers.

8.4.4.7 Evacuating the ITL

The ITL must be well insulated by a good vacuum to obtain very low temperature inside probe.

Push plunger knob upwards until it touches the vacuum plug. Screw clockwise **2 turns** the knob, not more. The plug is now attached to the operator plunger.

Switch on the vacuum pump (menu **Vacuum and LN_2**). Observe the vacuum level evolution that decreases. When the vacuum it is good (below 1 mbar) you can pull out the plunger to open the ITL vacuum valve.

The ITL is now being continuously pumped by the vacuum pump.

8.4.4.8 Pumping Exchanger Housing and Probe Transfer Line

Figure 8.11: Transfer Line Vacuum Valve Closed

- Open the vacuum valve of the transfer line. The valve is open when the axis of the handle is aligned with the transfer line.
- Open the vacuum valve on the exchanger housing.

8.5 Electrical and Gas Tubes Connections to Probe

8.5.1 Electrical Cables

- The probe base is equipped with a probe base heater (heats the top of the probe frame) and a waveguide heater (when the probe is equipped with waveguide). These heaters avoid the moisture condensation on the probe housing when the probe becomes cold.
- These heaters are permanently supplied with a 24 DC voltage. The heater cable must be plugged on the rear of the exchanger controller unit on plug “**probe heater**”.

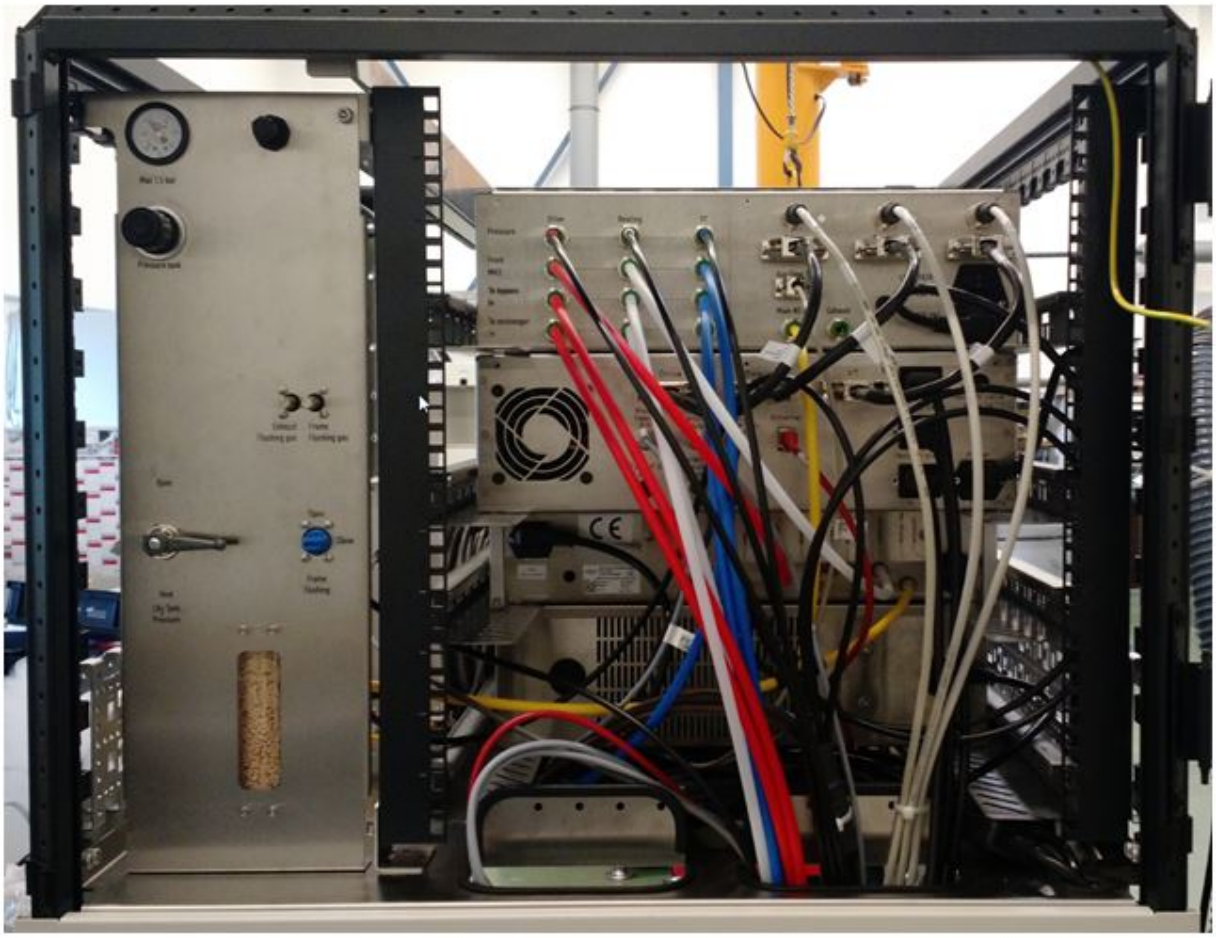

Figure 8.12: Rear View of Electronic Units

- The thermocouple cable “VT”, which measures the temperature near sample, and probe “exhaust” thermocouple cable, must be connected to the probe plugs marked (VT and EXHAUST).

8.5.2 Probe Gas Hoses

- The **INSERT** and **EJECT** gas hoses must be connected coming from cabinet and MAS2 unit must be connected to the corresponding probe base inlets.

- The probe base flushing gas must also be connected to probe to the “Base flushing” connector. It must be switched to “**ON**” (on rear left side of cabinet). The flushing gas avoids the moisture ingress in the probe bottom and creates a slight overpressure in the probe base.

8.5.3 Transfer Line Connection to Probe

Assemble both transfer line stands.

The transfer line is delivered with a metallic tube that protects the FRAGILE gas tubes ends. When the transfer line is not connected to probe it should be always protected.

Remove the protective tube.

⚠ CAUTION

Handling of the transfer line

Transfer line can be damaged. The thin stainless steel end tubes are extremely fragile.

- ▶ Be very careful while handling the unprotected transfer line. A mechanical shock or stress on these tubes can severely damage the transfer line termination or even destroy it.
- ▶ Install the protective tube whenever the line is not connected to probe.

The protective tube is attached to line with a seal and a clamp.

An o’ring seal is placed on each 6 mm tube end. These seals insure the tightness of the gas circuits and avoid the unwanted mixing of the MAS gases fluxes.

The position of the hole on transfer line and the pin position on the probe gas inlet port must correspond.

Insert carefully the transfer line inside the probe ITL. To align the three tubes with the three probe holes, grasp the transfer line close to the termination with one hand and with the other hand hold the line 60-100 cm further away.

If necessary move vertically up or down the transfer line with the second hand. A vertical movement rotates the three tubes around the transfer line axis. It allows the correct aligning of the tubes with the three probe holes.

When the tubes are in face of the holes, push in the transfer line slowly .Once the transfer line is completely inserted in the ITL, don’t move the transfer line anymore.

Keep the position of transfer line and install one stand about 50-70 cm away from probe. With the help of an assistant install and adjust the height of the stand to hold the transfer line in that position. Attach then the KF25 clamp to secure the transfer line on probe.

Unscrew the four cabinet feet to lock the cooling cabinet on the floor.

⚠ CAUTION

Risk of damage to transfer line

Once the transfer line is installed and connected to the probe, any further movement of the cabinet or line will induce mechanical stresses on the transfer line.

The cabinet **MUST NOT NO BE MOVED.**

If the transfer line is under stress it becomes very difficult to remove it from probe, the transfer line feels like literally blocked.

- ▶ If this happens it is recommended to move slightly the transfer line vertically up or down while trying to pull out gently the transfer line. Once a position is found that releases the mechanical stress, you can pull out easily the transfer line from the probe.

8.5.4 Flushing Exchanger and Probe

The exchanger coils and the probe should be flushed before filling the LN_2 reservoir and the chambers with LN_2.

Select the “**COOLING**” mode for all gases on touch panel in the ”**Run**” menu.

On the MAS2 keypad unit increase slowly the **BEARING** and **DRIVE** pressures to set the flow to approx. 5 l/min for **BEARING** and **DRIVE**. The actual flows can be read on the pneumatic unit front panel display.

The gases will flush the exchanger coils (that may contain moisture) and flush the probe before starting probe cooling. It is recommended to flush the probe with nitrogen gas at room temperature for at least 10 minutes prior cooling the probe to remove any contained moisture.

9 Software and User Interface

The cabinet has a touch panel on front side connected to the PLC controller unit. It is used to configure and control the whole cooling system operation. The user can pilot many functions of the LT-MAS cooling system.

9.1 Main Menu

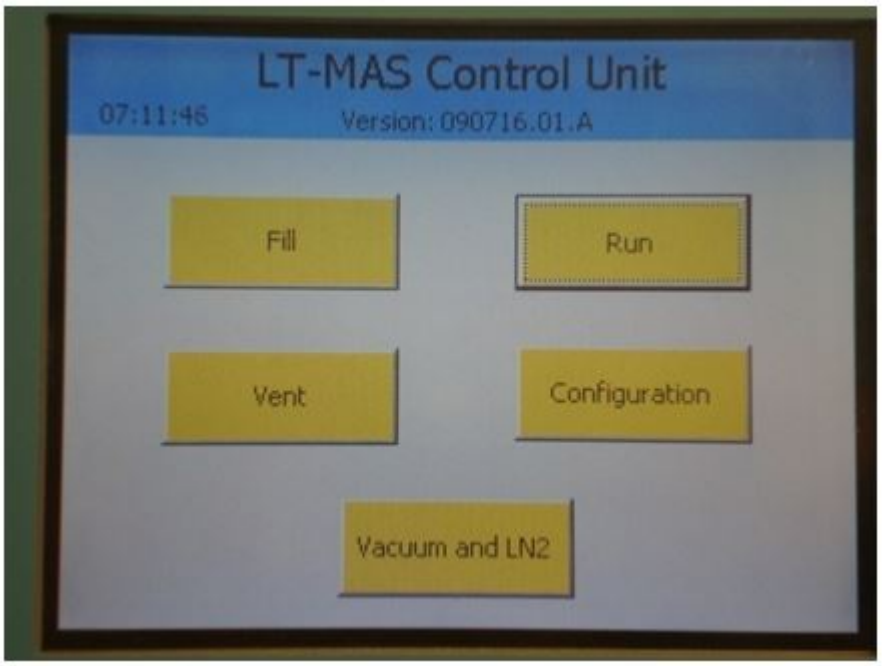

Figure 9.1: MAIN Control Unit Screen

This menu is automatically loaded upon system power up. It appears after approx. 30 seconds after system power up.

The main menu permits to select between several possible modes: **FILL**, **RUN**, **VENT** or **CONFIGURATION**. The **VACUUM AND LN2** menu is for controlling the operation of the vacuum pump.

The CONFIGURATION menu is only for service and its access is password protected.

The PLC exchanger controller firmware version is shown on top of the main screen.

The firmware version is encoded as YEAR MONTH DAY**.**

Ex: version 090716 = 16 July 2009

9.2 Vacuum and LN2 Menu

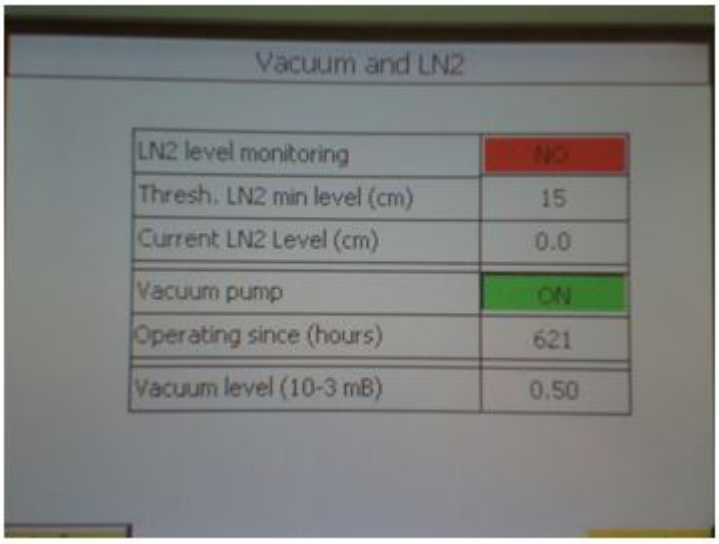

Figure 9.2: Vacuum and LN_2 Screen

Parameter	Description
LN_2 level monitoring	Yes (green) or No (Red). If enabled some functions like “Fill” chamber are disabled if the LN_2 level is below the threshold.
Thresh. LN_2 min level (cm)	LN_2 level that generates an error message when LN_2 level is low and the LN_2 monitoring is enabled.
Current LN_2 (cm)	Liquid nitrogen level in exchanger reservoir.
Vacuum pump	Can be switched “ON” or “OFF”.
Operation since (hours)	Timer of the vacuum pump operation.
Vacuum level (10 x 10^{-3} mbar)	System vacuum measured near the pump inlet.
Back	Pressing Back button returns to main screen

9.3 Fill Mode Menu

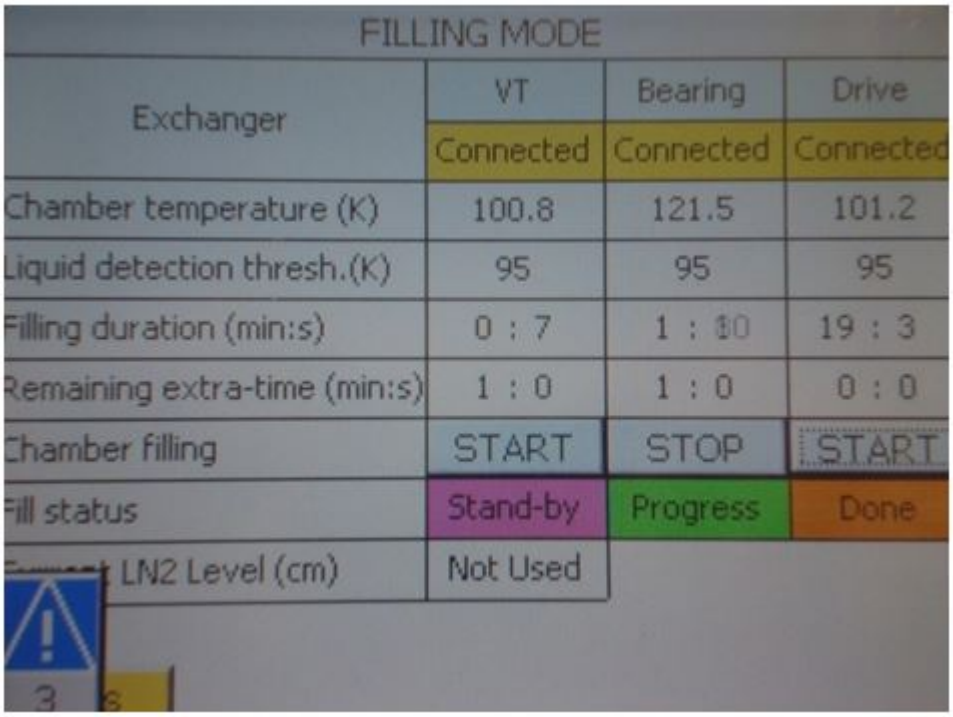

Figure 9.3: FILL Mode Screen

The FILL menu is used for the filling of the exchanger chambers with liquid nitrogen.

Before launching the filling process, check the LN_2 reservoir level. It must be comprised between level A and level B of AMI186 LN_2 level controller, in order to immerse completely the exchanger chambers.

The filling of the chamber with LN_2 is done by injecting nitrogen gas in the chamber. The nitrogen gas condenses in contact with the very cold chamber wall. The condensation of the nitrogen gas produces liquid nitrogen that progressively fills the chamber. The upper outer surface of each chamber must be always immersed in liquid nitrogen at 77K.

During the filling process the **FILL** valve of the chamber is open.

A Pt100 temperature sensor, slightly heated by a close resistor, serves to detect the liquid nitrogen level inside the chamber and measures later the temperature of the liquid nitrogen. Its temperature is typically between 95 K and 115 K when the sensor is surrounded by nitrogen gas and its temperature falls below the threshold temperature (set to 95 - 96 Kelvin) once immersed in LN_2.

Once the sensor has detected the liquid nitrogen, a countdown timer (named “**extra time**”) is started to make sure that the chamber level sensor is completely immersed in the liquid. The filling process continues until the end of the countdown.

All chambers must be filled before launching the **RUN** mode and before using the exchangers for the probe cooling.

	Description
Chamber temperature (K)	Temperature measured by a Pt100 temperature sensor in exchanger chamber. At the beginning of the chamber filling process, the Pt100 measures initially the gas temperature entering in the chamber, and later, the real liquid nitrogen temperature once the sensor is completely immersed in the liquid nitrogen.
Liquid detection threshold (K)	When the temperature is below this temperature threshold, it indicates clearly that the sensor is immersed in liquid nitrogen (threshold is set to 95K in configuration menu). If the temperature is above threshold, the sensor is surrounded by gas and the chamber level is low.
Filling duration (min:s)	Time elapsed since the beginning of the filling process.
Remaining extra-time (min:s)	This countdown counter is started once the temperature sensor has detected liquid nitrogen in the chamber. It starts when **Temperature < Liquid detection threshold**. The filling process continues until the end of the countdown.
Chamber filling	Pressing the button START starts the chamber filling process. STOP will stop the filling process
Fill status	Indicates the status of the chamber: • **STAND-BY** : chamber has not been filled • **PROGRESS** : filling process is in progress • **DONE** : chamber is filled and exchanger is ready for use. • **Error x**: Indicates an error occurred while filling the chamber. The code x indicates the type of problem
Infos	Displays general system information (flows, temperature, etc.)
Tank LN_2 level (cm)	Shows the liquid nitrogen level (in cm) inside exchanger tank. A capacitive level sensor attached to the level controller measures the level.
Back	Jumps to main screen. This button is not visible when the **FILLING** process is underway.

Table 9.1: Information contained in the Fill Screen

9.4 Information Window

This window shows general information of the cooling system. It is only available into the Fill and Run menu.

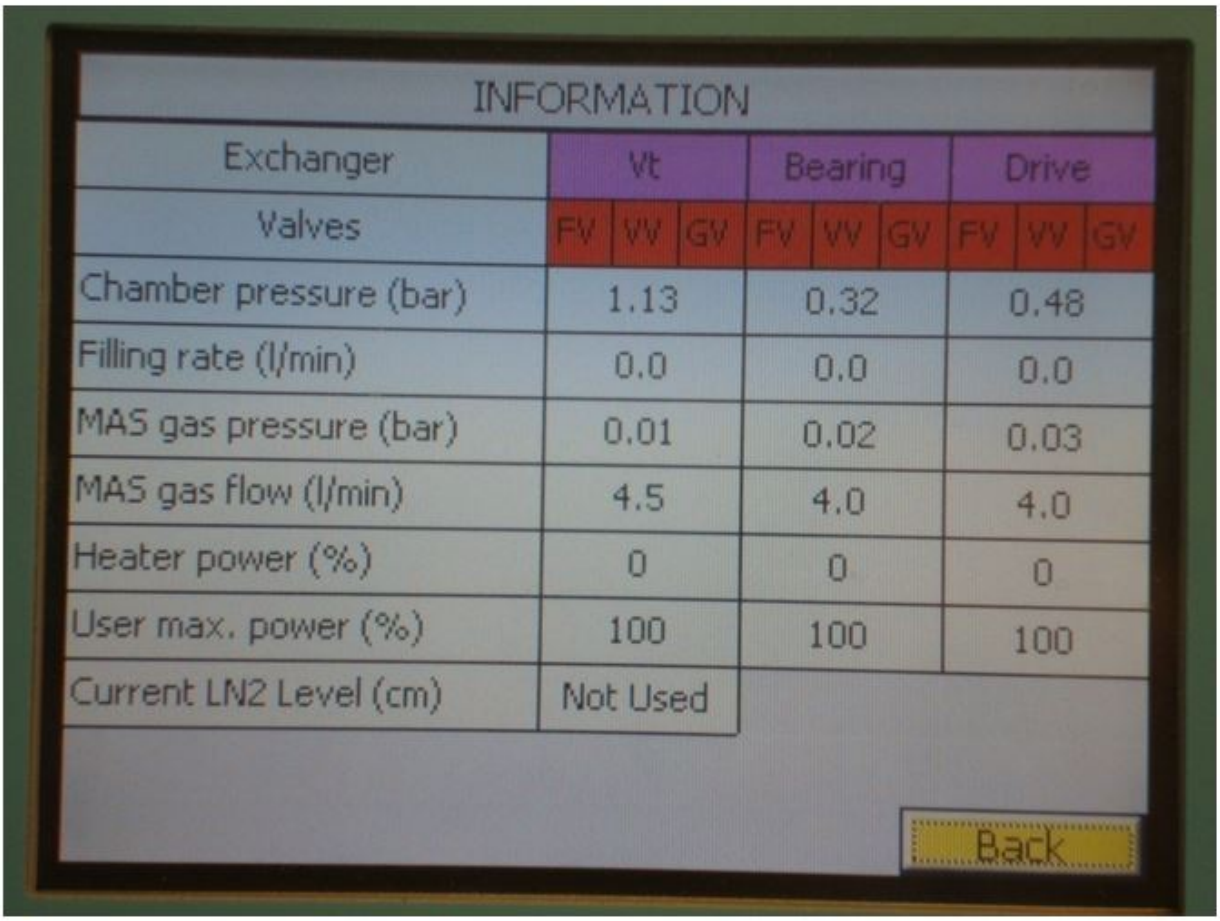

Figure 9.4: Information Screen

	Description
Valves	FV Filling Valve : red = closed, green = open VV Vent Valve : red= closed, green = open GV Gas Valve : red = by-pass; green = cooling
Chamber pressure (bar)	Actual chamber pressure (0...6 bar)
Filling rate (l/min)	Gas flow rate measured by the pneumatic unit upper flow meter during filling process
MAS gas pressure (bar)	Gas pressure measured in exchanger coil
MAS Gas Flow (L/min)	MAS gas flow measured by flow meter (lower row)
Heater power (%)	Actual chamber heater power in %
User max power (%)	Maximum heater power, can be changed by user (0…100%)
Back	Press the button to jump to main screen

9.5 Before Filling the Chambers

All three electrical cables must be connected between exchanger assembly and control unit. All chambers temperature must be consistent.

The system controller delivers the information "**X Chamber not connected**" when a temperature sensor is disconnected or broken. A normal temperature is between 70 K and 300 K. Beyond these temperature limits, the sensor is considered defective and generates an "**Error 3x**" on the screen (Error 31 for VT, 32 for drive and 33 for bearing chamber).

With an error "**Chamber not connected**" is indicated, it is neither possible to start a **Fill**, nor to switch to **Run** mode.

The value of the parameter "remaining extra-time (min: sec)" must be defined in the "Parameters setting".

The parameter "**Liquid detection thresh.** (K)" must be defined on page "Parameter setting".

The parameter "**Maximal duration**" must be defined on page "**Parameter setting**".

During the filling process:

- The cable connected to the chamber currently being filled should not be disconnected during the filling process. If it is disconnected, **"Chamber not connected"** message is displayed.
- The timer "**Filling duration**" shall not exceed the **"Maximum duration"** as defined in **CONFIGURATION** menu otherwise the filling process is stopped with an error message. If the time limit is reached, " **Error 6x Chamber filling time exceeded** " is shown and the fill valve is closed.
  The filling process can be terminated by pressing the **FILLING** button again.
- When the filling sequence is normally completed, the status changes to "**Done**". It means that the chamber is filled at the correct level and is ready now to be used in the **RUN** mode.
- If the filling process is not terminated normally due to an error (for instance maximum filling time exceeded, exchanger disconnected, etc.) the status of the chamber indicates "**Error x**".
  The code indicates the type of problem that occurred.

9.6 Vent Menu

This menu is used for service purpose only.

It is used for the venting of a chamber to release the gas pressure if the chamber pressure is too high, for example, or to lower the liquid nitrogen level contained in a chamber.

If the exchanger assembly needs to be removed from its reservoir, for servicing, the vent valve is opened to release the chamber pressure and evacuate all liquid nitrogen contained in the chamber.

To open a vent valve click on the valve button.

⚠ CAUTION

Risk of rotor crash

When the vent menu is pressed all the chamber heaters are automatically **SWITCHED OFF** and the chamber pressure is no longer controlled.

▶ When returning to run menu, the heaters **MUST** be switched **ON** again to control the chamber pressure.

9.7 RUN Mode Menu

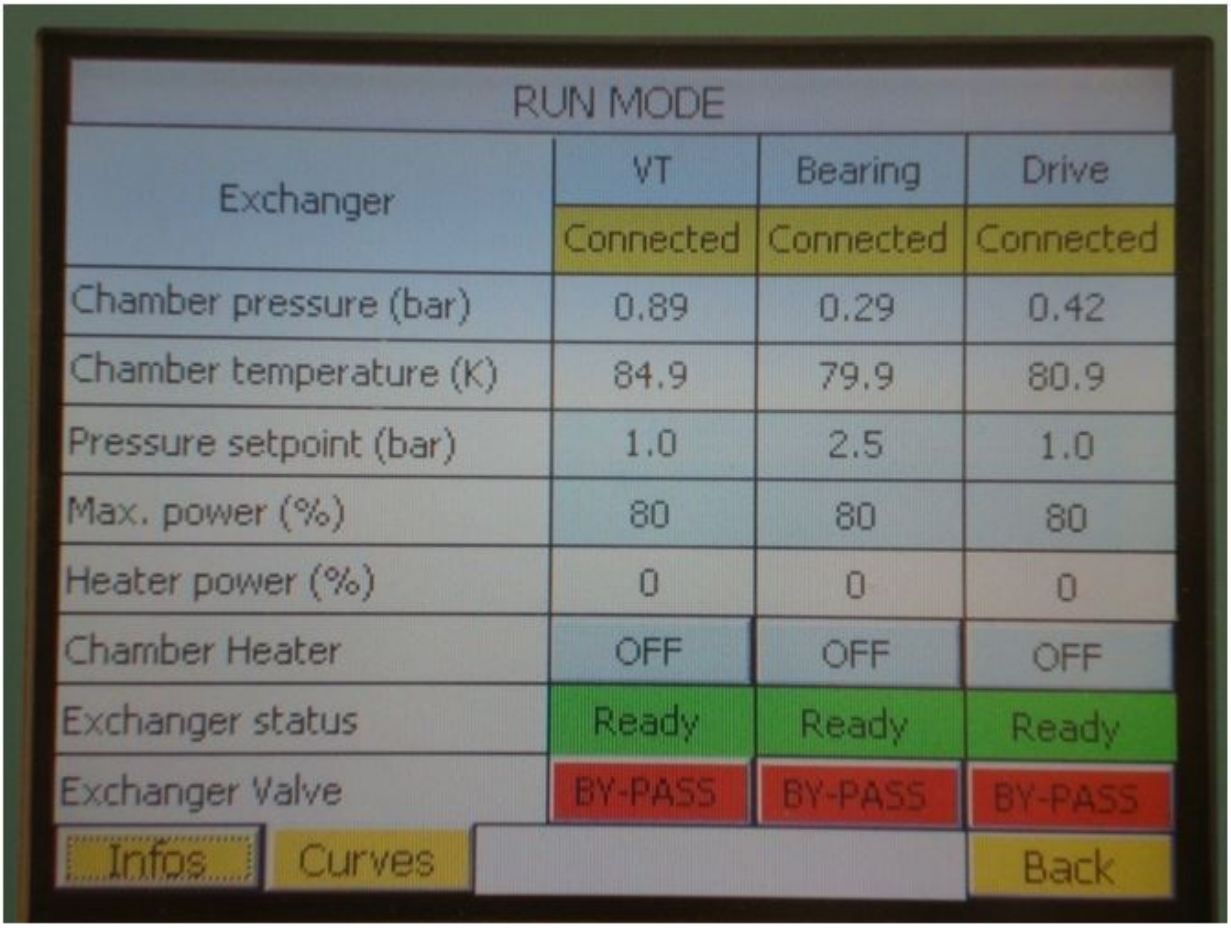

Figure 9.5: RUN Mode Screen

The RUN mode is used to set and control the chambers pressures. The chamber pressure is controlled only when the chamber heaters are switched “ON”.

It therefore controls the temperature of the boiling liquid nitrogen in all chambers.

Parameter	Description
Chamber pressure (bar)	Shows the actual chamber pressure. The chamber pressure is only regulated when the heater is switched **“ON”.**
Chamber temperature (K)	Actual temperature measured inside chamber.
Pressure set point (bar)	The pressure set point. It can be set between 0 and 4 bar.
Max power (%)	The maximum heater power. The maximum heating power will be limited to this value.
Heater power (%)	The actual heating power applied when the heater is **ON** for pressure control.
Chamber heater	Each chamber has a heater that can be switched **ON** or **OFF**. **ON:** means chamber pressure is controlled. **OFF:** pressure is **NOT** controlled; the chamber pressure will only depend on gas flow rate through exchanger coil.
Exchanger status	**Stand-by**: chamber is not filled; chamber heater cannot be switch ON. **Ready:** chamber is filled (the FILL menu status is DONE), the chamber heater can be switched ON.
Exchanger valve	The gas valve can be switched between two positions: **BY-PASS**: the gas doesn’t pass through the heat exchanger and is not being cooled. **COOLING**: gas flows through the heat exchanger coil and is being cooled.
Infos	Displays system information in a new window.
Back	This button jumps to main screen
Curves	Shows chambers several temperature charts

9.8 RUN Mode Use

The RUN mode is used to set and control the chamber pressure and consequently the temperature of the liquid nitrogen inside chamber. The pressure control is only possible if the chambers are already filled at the correct level.

The user must do the following actions:

1. Set "**Pressure set point (bar)"** of each chamber to the desired value. The minimum value is 0 bar, and the maximum is the limit defined by the parameter "Max set point pressure (bar)" in the window "Configuration ". It is limited to 6 bar max.
2. Adjust if necessary "Max. Power (%)", the minimum value is 0% and the maximum value is the value" User max. Power (%) " of the window " Pressure Regulators Configuration ". This parameter is limited to 100%.
3. Then, press the heater buttons to switch all chamber heaters to **ON**.
   If the chamber status is “**Ready**”, the system controller activates the heaters and controls the chamber pressure to reach the «Pressure set point". The chamber heater is disabled when the status is NOT READY.

10 LN2 Level Controller Settings

The LN_2 level controller unit is integrated in the PLC system controller unit and its front panel is visible.

- Set display unit switch to position “**Cm”,** to display the **LN_2** level in centimeters.
- Set refill levels high (“**A**”) and low (“**B**”).
  - Set high level “A” (typ. 37.5 cm), select “A” position, press raise or lower to change the value.
  - Set “B” low level (to typ. 36 cm), select “B” position, press raise or lower to change the value.

The A and B values here over are for the V2 and V3 exchangers. Please set A to 32 and B to 30 for V1 exchangers.

The level controller controls automatically the LN_2 level in the exchanger reservoir and insures that the level is always between level A and B to guaranty the correct operation of the exchanger.

LN2 Level Controller Settings

11 LN2 Supply Tank

Two main types of LN_2 storage tank style exist:

- "**RANGER**" type
- Normal tank with an opening of typically 50 mm.

A "RANGER" type is taller that a normal tank and has no removable part on top.

Install a full liquid nitrogen storage tank near the cooling cabinet.

The LN_2 insulated refill line is terminated by JIC female ¾" fitting and the tank must be equipped with a compatible male fitting.

11.1 How to Connect a "RANGER" LN2 Tank

Attach the pressurizing tubing from cabinet to the pressure inlet port on RANGER tank.

- Attach the insulated refill line to ranger port "LIQUID". The safety pressure relief valve near the cryogenic valve must always be oriented upwards.
- Set the pressure to 0.5-0.8 bar and check pressure on cabinet pressure gauge.
- Switch the pressure valve to position OPEN.
- Open the pressure valve on LN_2 supply tank, check pressure inside tank on pressure gauge
- The pressure in the LN_2 storage tank must be below max pressure of tank (e.g 0.7 bar). The storage tank is usually equipped with a safety overpressure valve that releases gas if the internal pressure is set too high.

11.2 Connect a Regular LN2 Tank with KF50 Opening

Install the LN_2 dispense plug (P/N 1803973) on tank with KF50 seal and clamp.

The dispense plug has three ports:

1. Liquid port (to withdraw liquid nitrogen).
2. Pressure port (to pressurize the LN_2 tank).
3. Vent port (to release the internal pressure).
   - Attach the tubing for pressurization coming from cabinet to the pressure port on storage tank.
   - Set the tank pressure to 0.5-0.8 bar and check pressure on pressure gauge.
   - Open the pressure valve in cooling cabinet.
   - Open pressure valve on LN_2 storage tank, check pressure inside tank.
   - The pressure must be below max allowed pressure in the tank (*e.g* limited to 0.7 bar).

11.3 Disconnect an Empty LN2 Storage Tank

11.3.1 Recommendations

Disconnection and reconnection of a full LN_2 tank should be done quickly.

Before disconnecting the refill line, switch to position CLOSED the LN_2 level controller to make sure the cryogenic valve remains **CLOSED** during the tank installation.

Connecting rapidly a full tank will limit the freezing of moisture air inside the cold cryogenic valve.

If the internal parts of a cold cryogenic valve are in contact with room air, moisture can condense inside and frost can build up. This can possibly cause later a malfunction or even a blockage of the cryogenic valve.

11.4 Disconnecting a “Ranger” LN2 Storage Tank

- Switch LN_2 level controller to “**CLOSE”** position.
- Close liquid and pressure valve on tank side.
- Switch the pressurization valve to vent for few seconds to release tank pressure from tubing.
- Switch pressure valve to “**CLOSE**” position.
- Disconnect tubing’s from pressure tubing.
- Disconnect the refill line.

11.5 Disconnecting a Regular LN2 Storage Tank

The tank pressure must be released before disconnecting any hose:

- Switch LN_2 level controller to “**CLOSE”** position.
- Close liquid dispense valve and vent valve on storage tank.
- Switch pressurization valve in cabinet to “CLOSE” position
- Open tank vent valve until tank has no pressure.
- Disconnect pressure tubing from vent port.
- Disconnect the refill hose and close the line with the delivered plug to avoid moisture ingress in cryogenic valve.
- Remove “dispense head” from LN_2 tank.

12 External LN2 Supply Line

Instead of using a LN_2 supply tank that must be refilled every day, the cabinet can be supplied directly by a fixed LN_2 line connected to a very large outdoor tank containing thousands of liter of LN_2.

The foam insulated line (2 m) delivered with the LTMAS cabinet is attached to the supply line termination.

The pressure of the LN_2 in the supply line should be below 1.5 bar.

The supply line provided by the customer MUST be equipped with 24VDC safety valve to close the LN_2 supply line in case of failure of the refilling controller or LT refill valve.

The safety valve operation is controlled by the safety refill controller (SRC) located in the side of the cabinet.

An optional Oxygen Gas Monitor can be possibly attached to the safety controller.

The SRC controller has a separate manual (P/N W161152).

External LN2 Supply Line

13 Getting Started

13.1 Filling the Exchanger LN2 Tank

The exchanger LN_2 tank has an internal capacity of 60 liters (100 l for exchanger V1). Connect a LN_2 storage tank containing 200 liters or more to the LN_2 refill line.

A tank pressure of 0.5 to 0.8 bar is necessary for the rapid transfer of LN_2 to the exchanger reservoir.

13.1.1 LN2 Supply Tank Pressurization

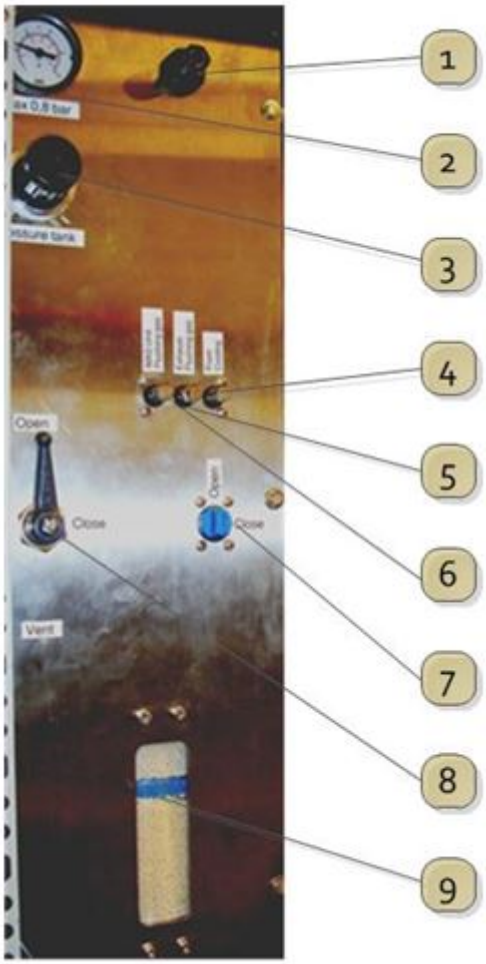

Figure 13.1: External LN_2 Tank Pressurization Panel

1	Pressure regulator (flush, mas II, and probe base flush)
2	LN_2 tank pressure
3	Tank pressure regulator
4	Flow valve exchanger exhaust flushing
5	Flow valve probe flushing gas
6	Flow valve MAS2 flushing (no longer used on recent systems)
7	Probe flushing gas switch
8	External LN_2 tank pressure valve
9	Gas dryer cartridge

The external supply LN_2 tank should be maintained at a constant pressure to permit the continuous filling of the exchanger reservoir. Usually the tanks can be self- pressurized but this mode doesn't function well the pressure may drop and stop the refilling of the exchanger reservoir.

We recommend pressurizing the tank directly from the LT MAS cabinet and not use the self-pressurization of the supply tank.

Connect the pressurization tubing from cabinet to the external supply LN_2 tank and switch pressure valve (8) to position **OPEN**. The LN_2 storage tank is usually equipped with a manometer. Pull out the regulator knob (3) and turn the knob to increase or decrease the pressure. Adjust the pressure on the pressure regulator to **0.5 to 0.8** bar.

When the pressure indication is correct, you can push in the knob to lock pressure regulator.

13.1.1.1 Supply Tank Pressure and Gas Panel

The pressure of the LN_2 supply tank can be controlled from the gas panel to maintain its pressure constant.

The pressure control is located on the rear left side of the cabinet. This panel has several components.

It has a drier cartridge (9) for the drying of the nitrogen gas. It removes the moisture from the nitrogen gas. The blue color of the moisture indicator indicates that the drier is not saturated. If the color indicator turns to pink, the drier material must be changed because the dryer agent is saturated.

On top right side a small pressure regulator (factory set) delivers nitrogen gas at a constant pressure to three gas flushing lines:

- Exchanger exhausts flushing.

This gas flow is used to protect the three exchanger exhaust chimneys against excessive icing.

- Probe base flushing gas.

This gas line is connected to probe base to flush it permanently and avoid moisture ingress.

- MAS2 flushing gas.

Used to flush internal volume of the MAS2 unit to avoid moisture ingress. No longer used on recent systems with MAS2 unit ECL3 or above.

The flows are set with the three 10 turns needles valve (4, 5, 6). The flows are set to approx. 10 l/min for each gas.

The probe base flushing gas can be turned off with the manual valve (7).

13.1.2 Filling the Exchanger LN2 Reservoir

Figure 13.2: Manual Reservoir Venting Valve

On top of the reservoir there is a safety overpressure valve (0.5 bar) and a manual venting valve.

The filling of a “warm” reservoir produces a large amount of cold nitrogen gas during the first minutes. The manual valve serves only to limit of the internal pressure raise in the reservoir during the initial filling.

Therefore the manual venting valve should be open for about 10 minutes until the level of liquid nitrogen rises in the reservoir. The level can be monitored on the LN2 level controller display.

Once the LN_2 level rises the valve should be closed again.

NOTICE

Please be aware!

For the correct operation of the exchanger the manual valve must be closed.

Switch the LN_2 level controller switch to position “**AUTO**”. The filling of the tank starts on level “B” and stops when the level “A” is reached.

The refilling of an empty tank initially at room temperature is fairly long and can last an hour. In contrast a reservoir containing only a few cm of liquid nitrogen is already cold can be refilled much faster.

13.1.3 Filling the Exchanger Chambers

Once the exchanger tank is full, all exchanger chambers can be filled with liquid nitrogen.

- Select the **BY-PASS** mode for all gases in the **RUN** menu.
- Click the **FILL** menu.
- Press **START** for all chambers VT, BEARING and DRIVE, the status changes to **PROGRESS**. When a chamber is filled, its status changes from **PROGRESS** to **DONE** (blinking message).

When all chambers are filled, the filling process is completed and the **RUN** mode can be used.

NOTICE

When the control unit is switched **OFF**, all chambers must be filled once to change the status of the chambers to **DONE** even if they are full.

13.1.4 Set Chamber Target Pressure

⚠ CAUTION

Risk of rotor crash

If the pressure of the chambers is not controlled it may produce a rotor crash due to gas pressure instabilities.

▶ Set all the chamber pressures targets and switch **ON** chamber heaters.

▶ Check chambers actual pressure before spinning the rotor.

Gas Name	Chamber Pressure Setting (bar)	MAS Gas Pressure @ 5 Khz (bar)
VT	1.0	0.7
Bearing	2.5	2.2

Gas Name	Chamber Pressure Setting (bar)	MAS Gas Pressure @ 5 Khz (bar)
Drive	1.1	0.8

Table 13.1: Example of Chamber Pressure Settings for a 3.2 mm LTMAS Probe

13.1.5 Preparation Phase before Measuring

1. Once the desired chamber pressures are reached switch the exchanger valve from “BY-PASS” to “COOLING”.
2. Increase BEARING and DRIVE from MAS2 unit up to **2 bar** and **1 bar** respectively to aid cooling the probe. At the same time increase the flow for the VT gas on the spectrometer console up to position 2000l/h to speed up the probe cooling. Set the temperature control on the spectrometer console to 90K for the VT, Bearing and Drive.
3. Leave probe to cool down and equilibrate.
4. After thirty to sixty minutes check the “VT temperature” from auxiliary sensor tab on the EDTE interface. If it is stable ~100 K then the probe is ready for use.

13.1.6 Rotor Insert Procedure

1. Insert a clean MAS rotor into a room temperature sample holder using a clean paper. The bottom part of the MAS rotor is marked with black and silver Sharpie pencils. The ceramic rotor cap is facing up into the sample holder.
2. On the MAS2 unit, reduce the Drive pressure to 0 mbar and the Bearing pressure down to 200 mbar. Reduce the VT gas flow down to 270 L/h in the TopSpin EDTE software**.**
3. Press the samples EJECT on the MAS2 unit and leave it on.
4. Remove the probe sample holder and replace it by the room temperature sample holder containing the MAS rotor to be analyzed. Twist the sample holder to fix it at the probe bottom. Make sure the sample holder is well fixed by pulling it down; it should not come out of the LT-MAS probe. The cold sample holder can be stored into the cooling cabinet, close to the MAS2 unit.
5. Stop the “Eject” flow on the MAS2 unit.
6. Press “Insert” during 5 seconds on the MAS2 unit.
7. When the MAS rotor is inserted properly into the probe MAS stator, the bearing flow should drop. If it is not the case, repeat step 10. until the MAS rotor is inserted into the MAS stator of the LT-MAS probe.

13.1.7 Start Rotor Spinning (for a 3.2 mm Rotor)

1. Increase the Bearing pressure up to 1.5 bar. The rotor should start spinning slowly.
2. Increase progressively the Drive pressure up to 300 mbar and then increase the Bearing pressure up to 2.1 bar. Adjust the Drive pressure to reach the target spinning frequency of the MAS rotor. The chambers pressure must be always 0.3-0.5 bar above the MAS gas pressure.
3. Turn ON the VT gas flow up to 30-35 L/min in the TopSpin EDTE software.
4. Finally, when the spinning frequency is stable and close to the target spinning frequency (+/- 10 Hz), switch to the “Automatic mode” on the MAS2 unit. Always change the spinning frequency in the “manual mode” of the MAS2 unit.

13.1.8 Rotor Ejection Procedure

1. Switch to the “Manual mode” on the MAS2 unit.
2. Decrease the VT flow down to 270 L/min in the TopSpin EDTE software.
3. Decrease the Drive pressure down to 0 mbar.
4. Decrease the Bearing pressure down to 0 mbar. The rotor should not spin anymore.
5. Increase the Bearing pressure up to 200 mbar.
6. Press “Eject” during 5 seconds on the MAS2 unit. The Bearing flow should increase when the MAS rotor goes out the MAS stator. Then stop the eject flow, the MAS rotor should fall down into the sample holder at the bottom of the LT-MAS probe.
7. Press “Eject” again and leaves it on.
8. Remove the sample holder which contains the MAS rotor. If the MAS rotor is not in the sample holder, repeat steps 21. and 22.
9. Replace a room temperature sample holder into the LT-MAS probe.
10. Stop the eject flow.

13.1.9 Probe Warming-Up

⚠ CAUTION

Risk to probe damage

If gas is not passing through the probe and the heaters are **ON**, internal parts of the probe (ITL) can be destroyed rapidly by overheating.

▶ Never switch **ON** the probe heaters in EDTE when the transfer line **IS NOT** connected to the probe.

- Remove the MAS rotor out of the probe (see procedure “rotor ejection” 11.1.8). To warm up rapidly the probe switch the gas valve to **BY-PASS** mode.
- Set the VT, Bearing and drive flows to **20 l/min** or more.
- Set all target temperatures to 300K in EDTE and set all heaters to 20 % of max power and switch ON the probe heaters.
- Once the probe has reached ambient temperature the gas flows can be reduced to 5 l/min and the probe heaters switched “OFF”.
- Flushing continuously the probe with nitrogen gas will avoid condensation inside probe.

13.2 Place Cooling System in Idle Mode

If the cooling system is not going to be used for days or over a night for instance, the following set up of the cooling system should be used.

- Switch all gases to “**BY-PASS** mode. Set gas flow to approx. 5 l/min for VT, bearing and drive to continuously flush the exchanger and probe.
- Switch OFF all chambers heaters.

NOTICE

Instable gas flow indication

In **BY-PASS** mode, gas at room temperature flows to probe directly. If the chamber heaters are turned **OFF** after some hours, some nitrogen gas will condense in the exchanger cold coil. Some LN_2 will slowly be accumulated inside the exchanger coil.

- ▶ Therefore when the cooling system is used again, it is necessary to eliminate the LN_2 accumulated in the coils. To flush the exchanger coils, switch ON the chamber heaters for a few minutes to boil off the accumulated liquid nitrogen. Gas flow indication may be instable for few minutes.
- ▶ The restart operation should be done **WITHOUT** a rotor inside the LT-MAS probe.

13.3 Removing Probe from NMR Magnet

Before removing the LTMAS probe from the NMR magnet, the probe ITL vacuum valve must be closed and the vacuum line disconnected.

The probe should be at room temperature before disconnecting the transfer line to avoid moisture ingress when the transfer line is disconnected. Warm-up the probe if necessary.

13.3.1 Closing Probe ITL Vacuum Valve

Push upwards the operator knob until you feel that the plunger pushes the plug inside vacuum port. The plug seals are squeezed and you can feel a slight resistance when the plug is engaged inside the vacuum port.

13.3.2 How to Disconnect the Vacuum Port Operator from ITL

Once the vacuum plug is pushed inside the ITL vacuum port:

- Unscrew the operator plunger by turning it **COUNTERCLOCKWISE** several turns (3 turns at least) to make sure it is completely disconnected from vacuum plug. Pull out then the plunger. You should not feel any resistance.
- **CLOSE** the manual vacuum valve.
- Loosen the vacuum operator nut and disconnect vacuum valve operator from ITL.

13.4 Safety Features of Exchanger Chambers

Several safeties systems are foreseen to avoid a chamber heater against overheating and serve to avoid a chamber overpressure.

13.4.1 Overheating Protection

If the chamber heater is “**ON”** and the chamber temperature becomes too high (e.g. > 105 K) it triggers an error condition. This error indicates that the temperature sensor is no longer in contact with liquid nitrogen and therefore the LN_2 level is low in the chamber. The chamber heater will be switched **OFF** automatically**.**

Exchanger status will indicate:

“Error 51" = "Low LN_2level in VT chamber”.

“Error 52" = "Low LN_2level in Bearing chamber”.

“Error 53" = "Low LN_2level in Drive chamber”.

When this error occurs it is necessary to fill again the chamber to enable the later reactivation of the heater.

13.4.2 Protection against Chamber Overpressure

Each chamber is individually protected by a mechanical pressure relief valve against overpressure.

- If the pressure in chamber is higher than **6 bar**, a mechanical pressure relief valve inside pneumatic unit is opened automatically and the nitrogen gas of the chamber is released to atmosphere. The safety valve limits the internal pressure of the chamber.

13.4.3 Max. Pressure Error Condition

The chamber pressure is also monitored by the system controller.

- The pressure in the chamber should not exceed the value defined by "**Max pressure allowed”** in the configuration menu.

In case of overpressure the following actions will take place:

- The chamber heater is switched **OFF**, the heater button indicates **OFF.**
- The vent valve (VV) will open automatically if this option is enabled in the configuration menu.

The status indicates:

- **“Error 21, Overpressure in VT chamber ".**
- **“Error 22, Overpressure in Bearing chamber ".**
- **“Error 23, Overpressure in Drive chamber ".**

14 Maintenance

Installation, initial commissioning, retrofitting, repairs, adjustments or dismantling of the device must only be carried out by BRUKER Service or personnel authorized by BRUKER. Damage due to servicing that is not authorized by BRUKER is not covered by your warranty.

14.1 Cleaning

As every electronic device, cleaning has to be performed carefully without using excessive water.

⚠ WARNING

Danger of injury from electrical shock

A life threatening shock may result when cleaning is performed inappropriately while connected to the line power.

- ▶ Switch the device off and disconnect from the line power.
- ▶ Prevent reconnection.
- ▶ After cleaning, wait until the unit is completely dry before you switch on again.

NOTICE

Potential damage of the device

- ▶ Clean the outside of the LT-MAS cabinet panels and the front touch panel with a soft, lint-free cloth slightly dampened in water. Potentially add a neutral cleaning fluid.
- ▶ Do not use any detergent or other cleaning solvents.
- ▶ Usage of cleaners like thinner or benzene may damage the surface of the unit.

14.2 Vacuum Pump Oil Replacement

The oil replacement is governed by a time counter. When the time limit is reached, a message will appear inviting the user to change the oil. Fresh vacuum oil is clear. Sometimes, oil quickly becomes dirty or dark due to severe usage. In these cases, don't hesitate to replace pump oil previous to the message invitation.

The time counter can be reset in the "Vacuum and LN2 level" menu.

Use only vacuum oil type A200 **P/N 79374** for 50 Hz operation.

If the vacuum pressure increases over time it is due sometimes to the quality of the vacuum oil that is degraded.

Figure 14.1: ADIXEN Rotary Vane Pump

The vacuum oil should be removed when the oil is warm and more fluid. Close all vacuum valves (exchanger housing, transfer line and probe) before switching off the pump.

- Remove the plastic cap on front side.
- Place a container under the pump (Adixen 2010I) to collect the used vacuum oil (1 liter capacity).
- Unscrew the fill plugs on top.
- Open slowly the front drain screw. When the pump is completely drained, close the drain screw.
- Fill with vacuum oil until the oil level is between the lower and upper level mark.

14.3 Drying Agent Renewal

When the drying material in the gas inlet filter is saturated, the color of moisture indicator (blue beads) turns to pink and the drying agent should be replaced.

Replacement procedure:

- Close main inlet N_2 gas valve on cabinet rear side.
- Disconnect all tubing from cartridge and remove cartridge from panel.
- Open the fill hole on top of cartridge with a large screwdriver.
- Flip cartridge and remove all drying agent.
- Fill it with new drying agent (white beads) up to lower mark on the glass.
- Fill then with moisture indicator (blue beads) up to high mark;
- Fill completely with white drying beads.
- Close the fill hole with the screw.
- Reinstall the cartridge on panel and reconnect all tubing.

15 Troubleshooting

This chapter explains how to troubleshoot LT-Mas cooling cabinet problems. If you cannot solve a problem using the steps given in this chapter, you should contact BRUKER.

Problem	Cause	Remedy
Cannot reach very cold probe temperature	Poor system vacuum because vacuum pump is off	Switch vacuum pump on
Cannot reach very cold probe temperature	ITL has a poor vacuum because actuator closed	Open ITL vacuum plug
Cannot reach very cold probe temperature	Exchanger vacuum valve is closed	Open exchanger transfer line vacuum valve
Cannot reach very cold probe temperature	Low gas flow through exchanger	Increase gas MAS flow
Chamber pressure not controlled	Heater is OFF	Switch ON heater
Chamber pressure not controlled	Heater does not function	Check heater resistance
Vacuum safety valve doesn't open	Valve fuse blown	Replace fuse on rear panel
Vacuum pump stopped	Motor overheating	Call BRUKER Service
Chamber cannot be filled	Ice blockage of filling hose inside exchanger assembly	Warm-up exchanger, remove internal blockage Call BRUKER Service
Poor system vacuum	Leak at ITL valve operator	Check ITL vacuum operator, replace seal in operator nut
Poor system vacuum	Safety valve has an internal leak	Check valve or replace valve near vacuum pump
Vacuum degradation, poor vacuum	Degradation of vacuum oil	Replace pump vacuum oil
Exchanger chamber empties quickly	Chamber seal has a leak	Replace chamber seal Call BRUKER Service
Exchanger chamber empties quickly	Leak in pneumatic circuit	Check tubing fittings Call BRUKER Service
High pressure inside chamber	Low LN_2 level in exchanger tank. Failure of LN_2 level sensor	Check LN_2 level sensor Call BRUKER Service

Problem	Cause	Remedy
High pressure inside chamber	Low level in Dewar, LN_2 controller switch is in close position	Switch controller to AUTO. Supply tank empty
High pressure inside chamber	Low level in Dewar, empty supply tank	Connect a full tank
Cryogenic valve does not open	Valve is not powered	Check cable connection
Cryogenic valve does not close	Cryogenic valve plunger is blocked by internal icing. Valve failure	Warm up cryogenic Valve. Test valve operation
Chamber pressure is not controlled	Chamber heater failure	Call BRUKER Service
Chamber pressure is not controlled	Chamber heater is OFF	Switch heater on
VTU Temperature sensor problem „**SBr**“ message	Temperature sensor failure	Call BRUKER Service
VTU Temperature sensor problem „**SBr**“ message	Exchanger cable disconnected	Check cable and connection
VTU Temperature sensor problem „**SBr**“ message	Condensation water on exchanger cable connector/ exchanger plug	Check and dry connector/ plug
Cannot refill exchanger reservoir	Cryogenic refill valve problem	Check valve fuse and valve cable connection
Cannot refill exchanger reservoir	LN_2 storage tank empty	Install a full tank
Cannot refill exchanger reservoir	Valve plunger is blocked by internal icing	Warm up valve, check valve operation or replace valve
Cannot refill exchanger reservoir	Valve is not powered	Check valve cable

16 Replacement of Parts

16.1 Spare Parts List

Bruker Part Number	Description	
W152827	Drier material with moisture indicator	Contains a bottle of drying agent and a bottle of blue moisture indicator beads
79374	Vacuum oil for vacuum pump (1 liter) A200 vacuum oil	For ADIXEN rotary vane pump
82248	O'ring seal VITON for ITL vacuum valve operator 9.25 x 1.78 mm	A seal is inside vacuum actuator
56939	O'ring seal VITON 6 x 1.5 mm transfer line to probe	Three seals are installed on transfer line tubes on probe side

Table 16.1: Spare parts list for the LTMAS cooling system

16.2 Shipping the Product

Follow these guidelines when shipping the product:

- **Use the original packing materials.** If the original shipping materials are not available, place a generous amount of shock absorbing material around the instrument and place it in a box that does not allow movement during shipping. Seal the box securely.
- Contact BRUKER before shipping the product.
- Prepay all shipping expenses including adequate insurance.
- Write the following information on a tag and attach it to the product:
  - Name and address of the owner.
  - Product model number and serial number.
  - Description of service required or failure indications.
- Mark the shipping container as **FRAGILE**.
- In all correspondence, refer to the instrument by model name or number and full serial number.

17 Dismantling and Disposal

Following the end of its operational life, the component must be dismantled and disposed of in accordance with the environmental regulations.

Installation, initial commissioning, retrofitting, repairs, adjustments or dismantling of the device must only be carried out by Bruker Service or personnel authorized by Bruker. Damage due to servicing that is not authorized by Bruker is not covered by your warranty.

17.1 Dismantling

Before dismantling:

- Power off the device and secure to prevent restarting.
- Physically disconnect the power supply cable from the device.
- Clean assemblies and parts properly.

Dismantle in compliance with applicable local occupational safety and environmental protection regulations.

17.2 Disposal Europe

Environmental information for laboratory and industrial customers within the EU (European Union)

This laboratory product is developed and marketed for **Business-to-Business** (B2B), so does not fall under article 6 clause 3 of the German Act ElectroG. To meet the demands of the European Directive **2012/19/EU WEEE 2** (Waste of Electrical and Electronic Equipment) and the national Equipment Safety Act, electrical and electronic equipment that is marked with this symbol directly on or with the equipment and/or its packaging must not be disposed of together with unsorted municipal waste or at local municipal waste collecting points. The symbol indicates that the equipment should be disposed of separately from regular industrial/ domestic waste.

Correct disposal and recycling will help prevent potential negative consequences for the environment and risk to personal health. It is your responsibility to dispose of this equipment using only legally prescribed methods of disposal and at collection points defined by government or local authorities in your area.

The WEEE register number can be found on the product label of the equipment. If you need further information on the disposal of equipment or collection and recovery programs available, contact your local Bruker BioSpin sales representative. Local authorities or professional waste management companies may also provide information on specific waste disposal services available in your area.

Disposal - End of Life (EoL) information: the common procedure as defined in the sales contract with Bruker BioSpin

After the lifespan of an electrical and electronic product, Bruker BioSpin takes responsibility for final disassembly and correct disposal in accordance with the European directive **2012/19/EU** WEEE 2.

Bruker BioSpin offers to take back the equipment (only for deliveries after 23.03.2006) after termination of use at the customer site upon request by the customer. This request must be affirmed when the equipment is ordered from Bruker BioSpin. Additional costs for dismantling and transport service will apply!

Only 100% pre-decontaminated equipment can and will be accepted by Bruker BioSpin. A release document for decontamination can be inquired from your nearest Bruker BioSpin contact site, also to be used when repairs, going back to Bruker sites, are requested.

In compliance with WEEE II directive: **2012/19/EU**

17.3 Disposal for USA

Disposal of these materials may be regulated due to environmental considerations. For disposal or recycling information, please contact our local office or your local authorities, or in the U.S.A., contact the Electronics Industry Alliance web site at *www.eiae.org*.

18 Contact

Manufacturer:

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WEEE FR311020911

NMR Hotlines:

Contact our NMR service centers.

Bruker BioSpin NMR provides dedicated hotlines and service centers, so that our specialists can respond as quickly as possible to all your service requests, applications questions, software or technical needs.

Please select the NMR service center or hotline you wish to contact from our list available at:

http://www.bruker.com/service/information-communication/helpdesk/magnetic-resonance.html

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